EDITION B

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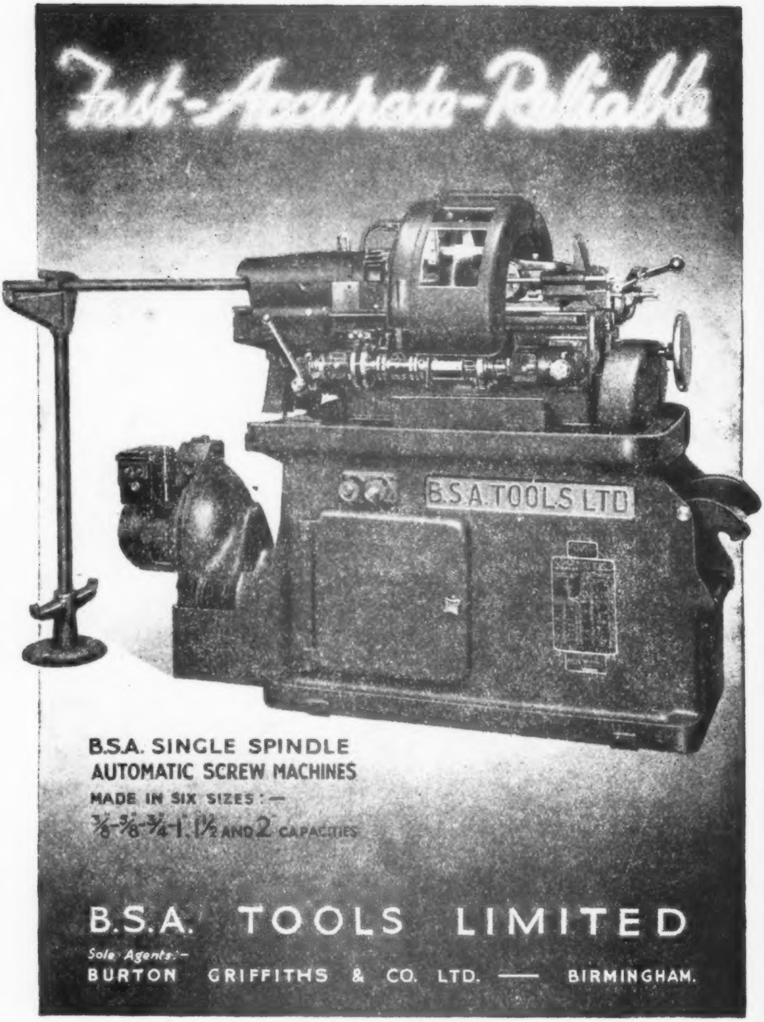
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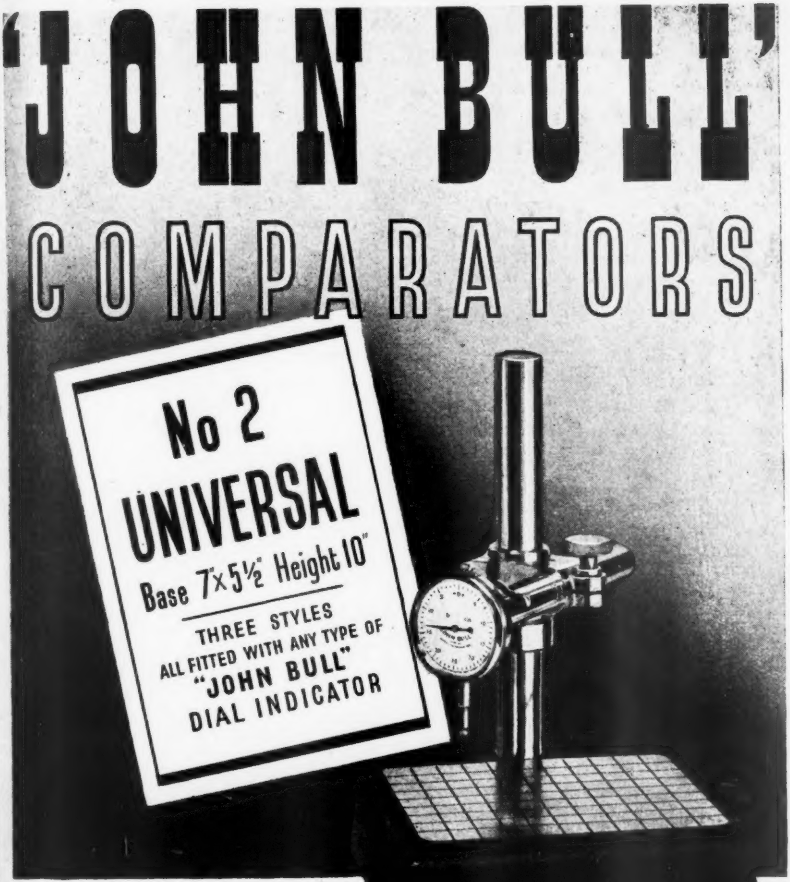

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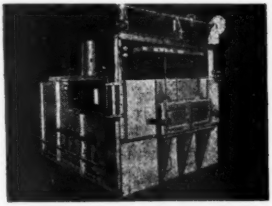

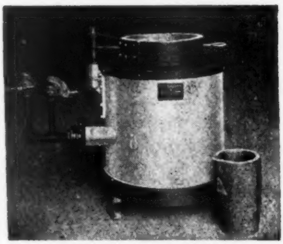

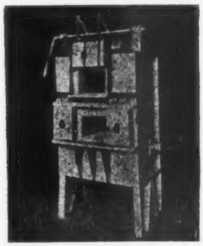

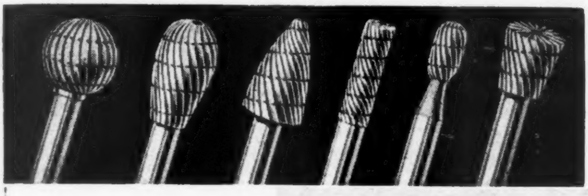


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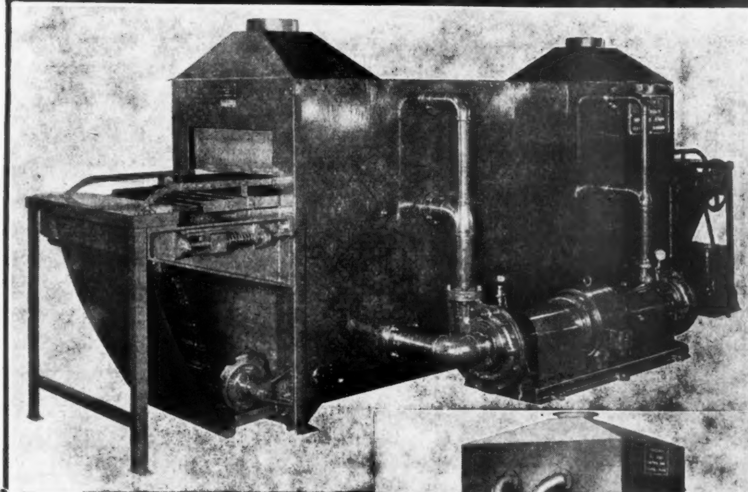

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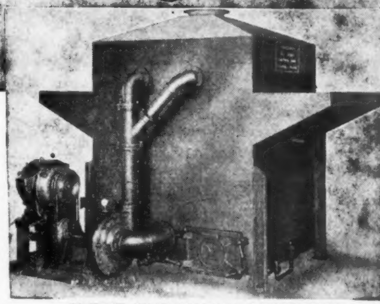

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A recently produced Dawson M.P.W. Machine for wire washing. One example of the multitude of uses for which these machines can be constructed.

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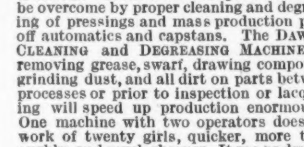
Dawson Deluge Washing-up Machines have been installed by scores of Engineering Works.



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Our Technical Dept. will gladly advise production Engineers on any washing process which could be introduced to increase efficiency of operation or speed up output. Enquiries with types of articles to be cleaned are invited.

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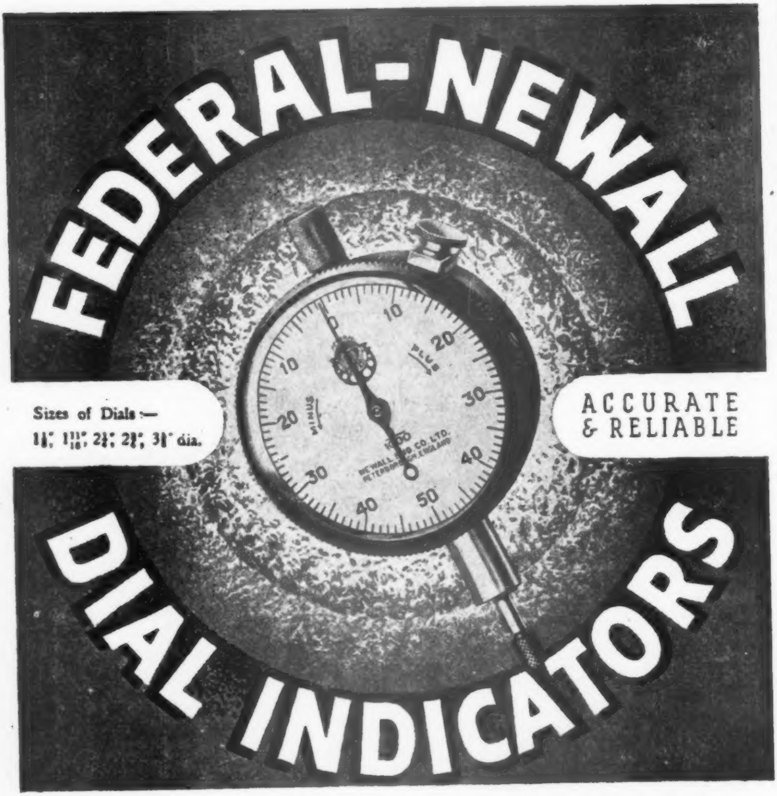
INDEX TO ADVERTISEMENTS

As a war-time measure the advertisement section of this Journal is now published in two editions, A and B. Advertisers' announcements only appear in one edition each month, advertisements in edition A alternating with those in edition B the following month. This Index gives the page number and edition in which the advertisements appear for the current month.

The fact that goods made of raw materials in short supply owing to war conditions are advertised in "The Journal" should not be taken as an indication that they are necessarily available for export.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INSTITUTION NOTES

June 1942

Fixtures.

July 4—Nottingham Section. Works visit to the Sheaf Iron Works of Messrs. Ruston & Hornsby, Ltd., Lincoln, followed by the Lincoln Engineering Society's sports meeting.

President-Elect, Sir Ernest Lemon, O.B.E.

Members will be pleased to learn that Sir Ernest Lemon, O.B.E. (Member) has been elected President of the Institution in succession to Mr. George Bailey, C.B.E., and will come into office at the annual general meeting later in the year.

Section Presidents—1942-43.

Birmingham Section J. W. Berry. *Cornish Section* C. D. Alder. *Coventry Section* H. D. S. Burgess. *Eastern Counties* A. E. Newby, M.B.E. *Edinburgh Section* J. L. Bennet. *Glasgow Section* I. Garvie. *Leicester and District Section* M. H. Taylor. *London Section* R. Kirchner. *Luton, Bedford, and District Section* J. R. Pearson. *Manchester Section* J. W. Davies. *North Eastern Section* W. A. Harriman, M.B.E. *Northern Ireland Section* A. Brown. *Nottingham Section* H. J. Gibbons. *Preston Section* R. D. G. Ryder. *Sheffield and District Section* S. R. Howes. *Western Section* J. S. Daniels. *Yorkshire Section* Major C. W. Mustill, M.B.E. *Sydney Section* J. Finlay.

Graduate Section Chairman—1942-43.

Birmingham Graduate Section R. E. W. Smith. *Coventry Graduate Section* F. Cotton. *London Graduate Section* R. F. Holland. *Yorkshire Graduate Section* G. R. Parker. *Loughborough College Student Centre* Dr. H. Schofield, M.B.E.

New Elected Members.

As Members: A. Bailey, A. Blair, A. J. Charnock, S. W. Dronsfield, C. J. Hyde-Trutch, J. K. Kendall, Sir Ernest Lemon, J. R. McLaren, B. S. W. Round, F. R. White, R. W. Whittle.

As Associate Members: J. Ayres, R. G. Boland, J. Barclay, R. Broadbent, G. Chadwick, N. Carnaghan, W. A. C. Carter, H. G. Cox, W. Dickie, H. G. Digweed, S. Evison, E. G. Eaton, J. Frazer, L. E. Glover, A. E. Godding, E. S. Gregory, R. G. Gray, H. Grigg, F. S. Hopwood, P. C. Kesteven, E. Marshall, W. E. Maynard, W. D. Opher, W. L. Oddy, G. Randall, M. R. Reeves, T. R. Smith, F. G. Scarlett, L. H. Sewell, R. Taylor-Thomas, K. E. Taylor, C. Toon, T. W. Turner, A. S. M. Wedderburn, J. F. White, E. C. Willmott, W. F. Webb.

As Associates: C. W. Adshead, R. Appleby, W. H. W. Bell, K. Colclough-Hoey, T. K. Cordes, E. J. Dowden, A. Elword, J. A. Gordon, M. P. Hardy, A. W. Hallpike, G. J. Lambard, R. H. Mead,

J. Pickles, A. Pickett, C. Roebuck, R. Robinson, J. Kershaw-Roxburgh, P. Sadler, T. B. Smith, C. Tewksbury, C. Timms.

As Intermediate Associate Members: W. R. Balchin, D. F. Bate, R. H. Burton, J. H. Bond, J. Birchall, J. W. Barrow, F. Beaumont, C. Bowden, G. Clarke, E. M. J. Concannon, G. A. Carter, H. G. Davies, R. E. Eldridge, J. E. Fogg, A. Houghton, F. A. James, C. M. Kennedy, J. Kenny, E. S. Kersey-Brown, W. C. Keen, W. E. Lewsey, G. E. Ling, D. Latham, C. W. Luck, E. E. Martin, T. Maude, R. W. H. Mark, W. McNeill, A. Marsden, C. Mason, T. Nuttall, A. L. Orchard, S. J. Parker, A. W. Rodaway, C. Standley, J. Saul, J. E. Stell, C. J. Thomas, M. H. Thomson, H. Thacker, R. A. Williams, F. Wilson, J. A. Walker, E. J. Wright.

As Graduates: P. Buchanan, E. Barron, N. Bradbury, H. Brewster, G. A. Bayley, G. F. Browne, A. J. Batten, E. F. Constable, F. T. Dyer, A. J. Deeley, H. J. B. Fisher, G. A. G. Garbett, J. L. Halldron, H. Holland, J. B. Hodgson, W. T. Howe, E. Jones, W. L. Jones, A. E. Kirton, W. Keeling, J. Laing, A. H. Mills, J. Moffat, F. H. Massiter, J. A. Nice, L. J. Rose, R. Scott, G. E. Trotter, N. A. Tope, G. Whittle, R. J. Williamson, J. S. Welsby.

As Students: F. D. Beesley, W. G. Carter, A. Davies, J. F. Dyson, D. R. Doughty, L. R. P. Francis, B. A. Gittins, G. E. Jackson, I. E. Jarman, H. Jaggers, G. E. Jackson, P. E. Kersting, C. W. Kealey, L. Luttig, D. A. W. Leech, D. L. Maier, S. Metcalfe, M. J. Noblet, F. Pickup, J. Parkinson, J. E. Pitchforth, O. S. S. Roberts, G. M. Smallwood, G. Shaw, R. C. Wood.

As Affiliated Firms: Cleveland Public Library, Dobson & Barlow Ltd., Howard & Bullough Ltd., Hayward-Tyler & Co.

Transfers.

From Associate Member to Member: A. H. Albu, R. W. Cantello, C. S. Cowap, B. H. Dyson.

From Intermediate Associate Member to Associate Member: E. Forrest-Brown, H. A. Colton, H. Hopper, G. Smithies, K. Watson.

From Graduate to Associate Member: J. R. Ferguson, W. C. Harper.

From Graduate to Intermediate Associate Member: W. Bradshaw, G. A. Daniell, R. A. J. Inns, R. N. Line, M. A. Moussa, F. H. Schofield, A. E. Taylor, E. R. Unwin, A. Wood.

From Student to Graduate: A. Short, G. R. Wimpenny.

Meeting of the Council.

The Council met in London on June 19, Mr. J. H. Bingham in the chair, and Messrs. J. W. Berry, J. Blackshaw, R. Broomhead, W. F. Dormer, H. A. Drane, E. P. Edwards, J. France, T. Fraser, G. H. Hales, F. W. Halliwell, H. A. Hartley, E. J. H. Jones, J. T. Kenworthy, R. Kirchner, Major Mustill, A. E. Newby, M.B.E., W. Puckey, M. H. Taylor. Also present Messrs. Buckle, Shenton, and White (Section Hon. Secretaries), Albu, and Stuchbury (London Section Committee).

INCREASING PRODUCTION WITHOUT INCREASING FACILITIES

A Memorandum presented to the Minister of Production by the Council of the Institution.

To CAPTAIN THE RIGHT HON. OLIVER LYTTELTON, P.C., M.P,
Minister of Production, WHITEHALL, S.W.1.

March 20, 1942.

SIR.—The Institution of Production Engineers has, on two previous occasions, addressed memoranda on production subjects to responsible members of the Government, and we have felt that these have contributed their small quota of help to the common effort. We now beg to address to you a further memorandum, in which we comment upon certain matters which we know to be of great importance in the present critical time.

Introductory.

During the first two years of the war the dominant characteristic of the production problem was the immense and intensified expansion of plant. New factories were built, old factories converted, machine tools imported in huge numbers, plants were dispersed or duplicated, until now it would be generally admitted that sheer expansion is nearing the limits imposed by labour availability, and that expansion is no longer the most predominant phase of the production problem. Indeed, with the entry into the war of the U.S.A. and the Russian need for machine tools, it is clear that our new focus of effort in home production must be to increase output without any further increase in plant facilities.

There are broadly only four ways by which this may be done, and this memorandum is written to direct attention to these fields. The four ways are: (1) By increased machine activity, (2) by simplification of design, (3) by rationalisation, (4) by improved manufacturing methods.

The last three of these are technical matters falling properly within the sphere of the Institution in whose name this memorandum is written, although the first involves labour matters, which is a subject on which the Institution would not normally presume to speak. Its excuse for doing so on this occasion is that any honest and knowledgeable comment aimed at increasing production should be acceptable in the present circumstances.

(*Vol. XXI, No. 5, May 1942.*)

1. Increased Machine Activity.

At a time when scarcity of machines was more dominant than scarcity of labour, it was proper to regard idle machine tools as calamitous. Now that scarcity of labour is at least equally critical, it is not always in the best interests of production to fill up idle machine hours. Such a course often, and particularly with small firms which are referred to later, results in the very uneconomical use of labour by reason of its working with inefficient production methods. Cases exist in which small firms are receiving orders for considerable quantities of screws made on capstan lathes and chucked in centre lathes for facing the heads. These screws will cost eight times their fair value made by proper methods. This point is made as a necessary qualification to what is to follow.

It is generally true throughout the country that total output is controlled by the output of machines. There are countless firms and organisations seeking assembly or bench fitting work, but there are few main contractors needing to sub-contract such work; this is because it is seldom a bottle-neck, is often done only on day shifts, and is always controlled by the supply of parts from machines. Generally, greater machine activity will mean greater total output. What, then, are the present facts regarding this vital machine activity? (*a*) The majority of engineering machine shops are working a nominal two-shift system of, say, fifty-five hours per shift week. (*b*) Many shops are working a day shift only. (*c*) There are new factories not possessing even full day shifts. (*d*) Three-shift systems or staggered shift systems are rare.

At first glance, these facts appear to indicate such a positive shortage of labour as to suggest the limit of machine activity has been reached. It is the fact, however, that the shortage is not so much a total shortage of labour as a shortage of labour for shift working. Few factories are short of labour in their day-shift shops (assembly and fitting and so on), but this labour is generally unwilling to be transferred to shift working, and current administration of the essential work order not only permits, but invites easy avoidance of the less convenient shift work.

If a higher percentage of whole time labour already at work were transferred to shift work, the vacancies on day shift could in many instances be filled by part-time workers, of whom many thousands are still available or could be made available. Part time workers cannot be used for shift work for obvious reasons.

We suggest that women of conscription ages should be classified, by consideration of the domestic situation, health, etc., and be specifically assigned either to shift-work or to day-shift. We believe that once a positive decision of this kind were given and enforced, the temptation to

avoid shift working would disappear, to the great advantage of machine activity and total output.

At present the weakness of national service officers, many of whom are hopelessly overloaded in exercising their powers, encourages not only the improper use of the medical certificate, which is unfortunately very common, but also encourages absenteeism and lateness. The loss in machine activity commonly amounts to between five and 10%, and this represents a similar or often a greater loss in total output. This matter is mentioned because it is related to the former point and cannot be omitted, but we consider that the solution suggested for the strengthening of shift-manning is of dominant importance, and would increase production in many cases more than 20%.

We believe that the great majority of employees throughout the country deeply resent the weak treatment of the minority who misbehave, and that a stronger disciplinary attitude would benefit general morale.

The problem of increasing machine activity cannot be attacked without mention of gaps in the production programme, and this involved element in planning bears differently upon large and small shops, upon main contractors and sub-contractors. A complete study of this wide subject is impossible in this short memorandum, but we wish to emphasise two matters.

The first was elaborated in part of a former memorandum which we addressed to the Rt. Hon. Arthur Greenwood, then Chairman of the Production Council, in September, 1940, because we believed, and still do, that this question has a profound bearing upon bringing about total production. We feel we must re-emphasise it now, and a reprint of the extract is, therefore, appended to this memorandum.

The second matter has reference to the smaller firms and to sub-contracting.

Only about 4% of all the engineering firms in England employ over 500 people. Two-thirds of all the firms employ less than fifty people. At the same time, about two-thirds of the total labour is employed in only 4% of the total firms. It is clear that under these conditions the problems, and consequently the best methods, of planning the production of the few big units must be entirely different from those of the thousands of small units.

Many, but by no means all, of the small firms are very inefficient, and new ones are growing up each day. This should be prevented. The fault is with the department or main contractor placing the orders with inefficient firms; for so long as such firms can secure orders at high costs they will generally oppose voluntary measures towards grouping or sole dependance upon one parent main con-

tractor. It is unfortunate that Government costing departments appear to concentrate upon the limitation of profit rather than of cost.

All these factors bear directly upon the machine activity of the small firm, which is frequently low because of the inefficient allocation of load to their capacity. We do not think the production programmes of the small units can ever be efficiently and individually planned from a central headquarters, much less from a multiplicity of Supply Ministries. *We recommend that the problem be tackled on a de-centralised basis, either by a wide extension of the powers of District Clearing Centres, or better, by the formation of District Production Groups responsible for the assignment of loads to capacities within the groups.* In this case, it follows that the Supply Ministries, in relation to such production groups, must be regarded as buyers in the broadest sense. They must develop and specify the particulars of the needed products and the groups are the " firms " from whom they are to buy and with whom they are to agree their production programmes. We visualise each group as a single firm, with the same freedom of movement of labour and plant within the group as is enjoyed by a single firm within itself.

2. Simplification of Design.

It is the normal thing, when increases in production of an article are called for, to follow the line of least resistance, and attempt to increase the machine hours assigned to the job *pro rata* to the increased production required, thus limiting the production to the total machine hours available. An alternative which has proved richly productive in certain instances is to modify the design both to facilitate production and to eliminate superfluities.

This is not a field which permits setting down rules or even guides, and success is largely dependent on the experience of the individuals concerned in each case. Any reasonably competent production engineer, however, will find scope for effort of this kind in probably every separate product with which he is concerned.

As regards changes in design to facilitate production, this is not a static question in which a single review will yield all the potentialities. The actual experience of a production order will suggest possibilities for repeat orders. An increase in the required rate of production will influence design, bigger quantities invariably encouraging simplification of design, and reduction of machine hours

Perhaps the more important side to this question is the elimination of superfluities. There is a tendency for designs to include elaborations which do not seem justified, bearing in mind the production load they represent. A few examples in this field are given below :

		£	s.	d.
(1) A Bren Gun Part :				
Original cost per 100 :	Material	4	7	6
	Man/machine hours ...	234	7	6
		238	15	0
Cost per 100 after re-design as a simplified pressing :				
Material		1	10	0
Man/machine hours		10	0	0
		11	10	0

This case represents a saving of 797,000 machine hours, equivalent to £204.975 over an order for 90,000.

		£	s.	d.
(2) Aircraft Part :				
Original cost per 100 :	Material	1	0	2
	Man/machine hours ...	4	4	10
		5	5	0
Cost per 100 after re-design all as one unit :				
	Material		14	2
	Man/machine hours ...	2	16	0
		3	10	2

This case represents a saving of 5,407 machine hours, equivalent to £1,346 over an order for 95,000. Total saving of material and machine hours over a quantity of 95,000 is £1,631.

		£	s.	d.
(3) Percussion Fuse Part :				
Original cost per 100 :	Material		2	6
	Man/machine hours ...		12	6
			15	0
Cost per 100 after re-design and die-casting :				
	Material		1	7
	Man/machine hours ...		3	10
			5	5

This case represents a saving of 77,480 machine hours equivalent to £17,334, over an order for 4,000,000. Total saving of material and machine hours over a quantity of 4,000,000 is £19,180.

(4) TWO-POUNDER GUN MOUNTING PART :

		£	s.	d.
Original cost per 100 :	Material	250	0	0
	Man/machine hours... ...	850	0	0
		1,100	0	0
Cost per 100 after re-design :	Material	68	6	8
	Man/machine hours .	180	16	8
		249	3	4

Apart from saving in machine hours and cost, this re-design has also eliminated the use of high-grade alloy steel.

(5) SIX-POUNDER BREECH MECHANISM PART :

		£	s.	d.
Original cost per 100 :	Material	1	2	6
	Man/machine hours ...	15	12	6
		£16	15	0
Cost per 100 after re-design :	Material		12	6
	Man/machine hours .	3	2	6
		£3	15	0

Practically the whole of the machine hours saved were milling machine hours.

(6) STANDARD AIRFRAME PART :

		£	s.	d.
Old method. Made from bar per 1,000 :	Material ...	4	1	9
	Labour ...	52	9	10
		£56	11	7
New method. Made from sheet per 1,000 :	Material	2	17	11
	Labour	15	11	0
		£18	8	11

This case represents a saving of 13,100 machine hours equivalent to £3,812 10s. over an order for 100,000.

	£	s.	d
(7) AIR-BORNE RADIO PART :			
Old method. Two off per unit pulley casting—cost per 100 units	7	1	8
Two off per unit brass gear—cost per 100 units	17	10	0
Six off six B.A. screws, six off six B.A. locking washers, cost per 100 units	2	10	0
	£27	1	8
New method. All above parts replaced by two off per unit pulley and gear die-castings—cost per 100 units	5	8	4

This case represents the elimination of all machine hours with the substitution of a die-casting: £4,333 6s. 8d. saved over an order for 20,000.

We particularly emphasise the savings in raw materials which have been realised in each of the above examples, making the changes doubly advantageous.

The need for interchangeability is frequently cited against re-design, although in the cases quoted it was not affected. In view of the advantages to production, however, it is a question whether net gains would not often be realised even at the cost of loss of interchangeability.

We recommend that the Supply Ministries should, as a matter of policy, devote constant attention to the potentialities of modifications to design in the case of all articles in continuous or big quantity production, and that this policy should always be adopted when increases in output are required. We believe the formation and extension of product groups is beneficial in this field of technical interchange of ideas. Product groups, in this case, need not control the placing of orders since their function is mainly that of technical co-operation.

3. Rationalisation.

By rationalisation we mean concentration so that plant, attention, and effort, are expended upon fewer things. The reduction in the variety of goods produced in each plant can be effected either by (*a*) extending standardisation on fewer types or (*b*) by sub-dividing production between fewer firms. Each firm then produces greater quantities of fewer types.

Let us consider for a moment the effect of multiplicity of variety in each production unit, and in order to draw out the significance of the matter, let us assume that the number of varieties of product are to be halved, in a typical organisation, while the total weekly value of production is to remain unaltered.

Department	*Function*	*Effect of halving variety of product with same total output*
Production planning.	Analysing orders, creation of shop schedules and programmes, maintenance of stock records.	Half the work to do, in all stages.
Production engineering.	Determination of manufacturing methods, design of tools and fixtures, design of shop layouts.	Half the products to plan, half the tools to design.
Tool room -	Manufacture of tools and fixtures.	Half the variety of tools to make and to maintain.
Machine shops	Manufacture of parts.	Half the schedules, therefore half the setting up.
Assembly or fitting shops.	Assembly of finished product.	Half the variety of operations, therefore half the training of operators.
Inspection -	Examination of finished product.	Increased efficiency as a result. Less supervision needed.
Stores - -	Location of stocks and pre-selection for issue to assembly.	Half the records to keep and reduction in storage bins.
Purchasing -	Purchase of all materials and outside supplies and chasing of delivery.	Half the enquiries to originate, half the orders to place or chase.
Progress - -	Checking the performance of production shops. Chasing where necessary.	Half the schedules to go wrong and chase.
Accounting -	Payroll. Cost checking.	Half the piece-work earnings to compute. Half the costs to check.

Comparable advantages would, of course, also arise in Government production departments affected.

Attention tends to be focussed so narrowly upon the shortage of productive labour that the importance of the so-called non-productive staff, which is even scarcer, is not fully realised. Much of the non-productive work in each engineering factory is highly skilled work, and this effort is just as surely dissipated through over diversified production as the time of skilled tool makers or other skilled producers. Productive capacity is not to be measured in machine hours alone, but also in administrative capacity, production planning capacity, production engineering capacity, and even in skilled clerical capacity. Efficiency in big production shops cannot exist without the skill and adequacy of the corresponding production planning and administrative effort. If there is a national shortage of skilled management, as of almost every other skilled occupation, let the same care be taken to avoid its wastage or dissipation as is emphasised for the skilled producer.

We cannot say, in so many words, what is an optimum span of variety of products for each establishment, the equation is too involved. We can, and do say, that the optimum is far from being achieved in most factories other than those making a single special product for which they were created. We know that the resulting weakening of concentration upon the problems of each product represents a real and important loss in production. We believe that the spreading of contracts under the influence of bombing risks has been overdone, and in addition that a policy of planned concentration of production, within reasonable limits, would result in a significant reduction in the variety of products in many works, with a corresponding increase in efficiency.

We will elaborate a little some detailed considerations which arise under our two sub-divisions of the field of rationalisation.

(*a*) *Standardisation.* This word conjures up a picture of the British Standards Institution, and of all the excellent work it does; work covering the standardisation of performance as well as of dimensions and design. The valuable, freely given time of the experts co-operating under the B.S.I. is an important contribution indeed. The recent decision of the Ministry of Aircraft Production to appoint a Deputy Directorate of Standardisation is encouraging. Yet the field of saving and so of increased production yet untouched is immense.

It is strictly relevant to glance at some recent standardisation achievements so as to be impressed with their obvious returns in simplified production in industries other than armaments.

(1) *Directorate of Building Standardisation.*
Doors. Number of patterns in production reduced from 40 to four, and the sizes from 20 to eight.
Steel windows. Standardised and many fewer types in production.
Bricks. The sizes in production reduced from 17 to two.
This directorate has published a schedule of war-time building supplies, to prevent avoidable specification of special equipment.

(2) *Department of Scientific and Industrial Research.*
Buildings of standard types using standardised steel sections have been designed, and new war-time factories are, wherever possible, built within these standards.

(3) *Board of Trade.*
Holloware. Orders have been issued calling for standardisation in the manufacture of holloware. These orders significantly forecast increased supplies and reduced costs as a result.

(4) Cadbury's have given national publicity to the big reduction in labour and floor space they have realised by concentrating production upon many fewer varieties.

(5) The perambulator industry have collaborated in the design and manufacture of a "standard pram," with considerable economy in machine hours per unit.

These are sufficient examples to press home the claim that great efforts in the same direction will produce similar obvious benefits in the armament production field. Must there be such a wide range of machine tools themselves? Must there be more than three hundred different types of collets, because some designers of capstans have considered it disadvantageous to fall in with a rival's standards? Must there be a separate design for each of the three Supply Ministries of so simple a thing as a morse tapper?

We are far from inferring, therefore, that efforts and results are not to be found in the important sphere of standardisation. The returns for further work are of such importance that we feel justified in pressing for even greater co-ordination, even more determined efforts.

(*b*) *Simplification of the production programme.* We have already mentioned the bearing upon the variety of the programme in individual works, of the policy of spreading production for safety first reason. The premium being paid for this insurance may possibly be justified, but it is indeed a high one.

The spreading of contracts does not always result from this policy. Often it comes about because the existing programme of a suitable manufacturer leaves him insufficient spare capacity to

undertake the whole of a new demand. In this case, the requirements are again divided, placing with him the share he can do, and the remainder going elsewhere. This kind of action can only be prevented by a thorough over-all planning of the entire programme of each works, which is the kind of effort seldom or never made.

A large manufacturer was recently urged by a Supply Department to augment his output of a particular product, and his reply was . " We make such a variety of items that we cannot undertake to increase our output of this particular product." So yet another producer was tooled up, and each one of them was operating at reduced efficiency through having shorter runs. Such examples are common.

Yet in the case of some products, the rationalisation efforts which have been made have been excellent, and have turned production shortages into surpluses, or have greatly eased bottle-necks. Examples are aircraft bolts and nuts, radio valves, and wires. It is important to note that although such rationalisation efforts may concentrate the production of certain sizes in only one or two works there is still a reasonable margin of safety. The transfer back to the first works of the manufacture of sizes which they had formerly made, but had given up in the interests of rationalisation, involves no fundamental obstacles but only the transfer of tools and material. In the face of this, it is astonishing that it is still common to receive allocations of ball bearings, which are in short supply, of the same size from four different bearing manufacturers.

We must emphasise strongly that production is still largely controlled by tool making capacity, and failure to rationalise is a great source of unnecessary tool load.

We recommend that most serious reconsideration be given to the abandonment of the safety first policy in spreading contracts and that the general policy should be rather to concentrate production as much as may seem justified. While a single source of supply for any article would, of course, be inadequate, we recommend that two or three would often be sufficient. Where additional sets of tools exist, their lodgment in dispersed locations would serve as an additional insurance.

Where contracts are to be split because a manufacturer has insufficient spare capacity to undertake the whole, we particularly urge that a review should be made of his whole programme. Efforts would then be directed towards planning for a maximum concentration of programmes by pairing up some other commitment with a similar contract elsewhere

We have a strong conviction that the placing of production programmes is a highly specialised matter, and that it will only be well done with at least the close advice, if not the direction, of persons thoroughly understanding the principles of production.

Above all, we beg that if manufacturers do run into production gaps, they should not be handed out almost anything "to keep them going." Such panic measures create just the troubles which give rise to production gaps.

4. Improved Manufacturing Methods.

The benefits to production of introducing improved manufacturing methods are obvious and need no urging. The reduction in machine hours through this approach can be very high. Production engineering knowledge, as all professional knowledge, takes many years to acquire, and there is no short cut by which quick training may fill the deficiency.

An immense number of small firms lack adequate production engineering experience. But since they have usually only a small spread of products, the deficiency could be met by making available to each of them periodically a few hours of the time of a production engineer specialising in their particular class of manufacture.

This Institution has already offered just such voluntary assistance with the enthusiastic support of hundreds of its members. These offers appear to have been ignored or else met negatively by stating difficulties and inviting alternatives which, however, are generally not in effect. The positive approach would be to give the Institution's offer a trial. We realise, of course, that the Supply Ministries deal mainly with main contractors who are less in need of technical advice than the thousands of small firms. The organisation of, or even the discovery of the need for, technical advice is unlikely to be effected until a de-centralised control of production is instituted. Nevertheless, with our widely scattered membership, we are confident that we could make help available, either through our members or their staffs, and thus support and strengthen the less experienced producers in their own neighbourhoods.

Some of the duties of the centralised technical directorates, e.g. of the machine tool control, must necessarily be of a critical nature, such as, for example, forcing changes in or withdrawal of unused plant or labour. In our view, critical action of this kind is best taken by an official of the Ministries and not by a voluntary adviser. The services of the latter could, however, be widely and very beneficially used when the objectives are obviously constructive and non-controversial.

We have already referred to the benefits of integrating together Product Groups of firms making similar products. We would reiterate that such Groups would be bound to have great value in spreading a knowledge of improved production methods.

In conclusion, we recommend that steps be taken immediately for the utilisation of the voluntary advisory services of our members, which can be made available in the way indicated.

We offer also the use of our Institution's branch organisations all over the United Kingdom, and would like to go on record that generally we are eager to augment the nation's production strength in every way that our training and experience makes possible.

We have the honour to be, Sir, yours, etc.,

Members of the Council of the Institution of Production Engineers.

SEMPILL, Deputy-President.

N. V. KIPPING, Chairman of Council. Works Manager, Standard Telephones and Cables, Ltd.

ALFRED HERBERT, Past-President.

T. M. BARLOW, Director and General Manager, Fairey Aviation Co., Stockport.

J. W. BERRY, Works Director, Birmingham Aluminium Castings, Ltd.

J. H. BINGHAM, Director and Works Manager, Metropolitan Gas Meters, Ltd.

J. E. BLACKSHAW, Engineering and General Manager, G. D. Peters & Co. Ltd.

D. BURGESS, Works Manager, A. C. Wickman, Ltd.

J. W. DAVIES, Director and General Works Manager, Ferranti, Ltd.

H. A. DRANE, Technical Engineer, Alfred Herbert, Ltd.

E. PERCY EDWARDS, Director, Weatherby Oilgear, Ltd.

J. FRANCE, Assistant Mechanical Engineer, Royal Arsenal.

T. FRASER, Works Manager, Metro-Vickers Aircraft Factory.

J. R. GIMSON, Joint Managing Director, Gimson & Co. (Leicester) Ltd.

G. H. HALES, Managing Director, George H. Hales Machine Tool Co. Ltd.

W. A. HARRIMAN, General Works Manager, A. Reyrolle & Co. Ltd.

H. A. HARTLEY, Director and Works Manager, Reavell & Co. Ltd.

E. J. H. JONES, Works Manager, Associated Equipment Company.

J. T. KENWORTHY, Technical Liaison Manager, Bristol Aeroplane Co.

C. W. MUSTILL, Works Director, Jackson Boilers, Ltd.

A. E. NEWBY, M.B.E.

W. PUCKEY, Works Manager, Hoover, Ltd.

H. SCHOFIELD, Principal, Loughborough College.

J. R. SINCLAIR, Plant and Production Engineer, Lockheed Hydraulic Brake Co. Ltd.

J. W. WALKER, Works Manager, Sanderson Bros. & Newbould, Ltd.

F. WILLIAMS, Director and Works Manager, Markham & Co. Ltd.

I. H. WRIGHT, Machine Tool Designer, Jas. Archdale & Co. Ltd.

Appendix

Extract from the Memorandum on War Production Problems Presented to the Rt. Hon. Arthur Greenwood, P.C., M.P., Chairman of the Production Council, September 2, 1940.

THAT STEPS SHOULD BE TAKEN TO IMPRESS UPON THE PERSONNEL OF CONTRACTS DEPARTMENTS AND PRODUCTION DIRECTORATES CERTAIN OF THE BASIC PRINCIPLES OF PRODUCTION WITH THE OBJECT OF UTILISING THE PRODUCTIVE CAPACITY OF INDUSTRY MORE EFFICIENTLY THAN AT PRESENT; AND THAT WHERE ORDERING IN BIG VOLUME IS CONTEMPLATED, A PARTICULAR SYSTEM OF ORDERING SHOULD BE ADOPTED.

Pre-Production Preparations

Production may generally be classified under three headings :—

(*a*) Jobbing, which is the production of special very small quantities, such as model making.

(*b*) Batch or Volume Production, which is the production of small or large quantities with the aid of tools designed to suit the quantities ordered and subject to repetition on a similar scale of ordering.

(*c*) Continuous Production, which is the "straight line" or flow production carried out with the aid of more elaborate tools, sometimes with special machine tools, and involves the organisation of production in such a way as to aim towards the permanent balance of the plant involved.

Both classes (*b*) and (*c*) must inherently be founded upon some reasonable knowledge of the total duration of the production of the article concerned. Both the rate of flow and duration of the job are essential basic factors on which all planning will be built.

Each of these classes of production will range within its own extremes according to the quantity to be produced and the size and character of the product and the very decision into which class a given product will fall must be based upon a reasonably accurate knowledge of the total volume of requirements. Failure to foresee these requirements is likely to result in inefficiency in planning and later in production because of the wrong choice of the basic class of treatment which the project is to receive.

Tooling for Production

In view of the wide range of possibilities outlined under the above three classes it must be emphasised that the term " Tooling for Production " does not have any one meaning but indicates a range of possibilities, the choice of which is mainly based upon the required volume, rate of flow and continuity of orders indicated at the time the job is first planned for production.

As a concrete illustration of the misunderstandings which can arise due to lack of appreciation of this point, a case recently occurred in which a certain Production Directorate had instructed two firms to " Tool up " for the same product. The initial orders were for 200 from firm " A " and 1,000 from firm " B." The firm " A " proceeded to tool up for a production of 50 per week as they had been instructed that there was a likelihood of future orders at that rate. The production was planned and tooled for an existing Instrument Shop as the type of product and the output suggested was suitable for that method of production. The firm " B," who received the initial order for 1,000, were in the habit of handling volume production using semi-skilled labour backed by efficient tooling and proceeded to tool up the order in accordance with their normal manufacturing procedure. The increased tool cost incurred by " B " was largely offset by the additional labour cost incurred by " A " owing to the different character of " A's " tooling. The demand for the product ultimately proved to be vastly in excess of the 50 per week on which basis " A " had tooled up but, fortunately for the Production Directorate concerned, the firm " B," owing to the different initial approach to the job and consequent more adequate tooling up, were able to meet the demands. On the other hand, the Production Directorate were very much disturbed to find out that while both firms had been instructed to tool up for the same product, one was unable to produce at a greater rate than the 50 per week while the other firm was able to meet a much larger demand.

In effect, therefore, it is necessary in the initial stages of production to reach an understanding with firms regarding the rate of production and class of method which will be used in order to ensure that the means for production of the product concerned are in line with probable future requirements as regards rate and duration of output. Different approaches to the same job will result in widely differing possibilities for expanding production.

Continuous or Flow Production

Basically, continuous or flow production involves the settling of plans within a factory which enable the product under consideration to be continuously produced from start to finish and for all operations to flow at an equal rate or to take place at uniform

intervals of time. Such preparations and planning are complex and are seriously dislocated if flow is interrupted.

There are in Great Britain not a great many factories organised on the basis of complete flow or line production since such organisation requires very heavy and continuous demands which, in this country, seldom arise. It is more common to find a factory organised so that flow characteristics are wherever possible obtained although the products on which the factory is engaged consist actually of large volumes of a variety of articles. The essential point is the necessity, in any large volume production, for the organisation to be built around the basic ideal of production flow. Each of the multitudinous production channels within the factory must be regarded as a pipeline through which production must flow and any temporary stoppage to that flow must involve a reduction in the total output attained which can never be regained. Emphasis must, therefore, be laid upon the fact that consciousness is one of the basic necessities in successful volume or continuous production. *It is this feature, perhaps beyond all others, which appears to be least appreciated in Production Directorates and which is the greatest cause of loss of output in the supply of Stores to Government Departments.*

In elaboration of this point, whether the factory is organised for complete continuous or flow production or for the volume production of a variety of products on a flow basis, the planning, including the organisation and synchronisation of materials, machinery and man power in such a way as to get the best balance of plant utilisation is complicated. It is not a thing which can be constantly modified because of fluctuations in the idea of the production flow required or because some Department has failed to renew orders in sufficient time to permit the mass of detail involved to be revised.

It is, in fact, utterly wrong where big volumes are concerned to talk of orders of some fixed quantity of the product. It is necessary to talk of the RATE of production which is being ordered with some reasonable indication of total duration. Manufacturing organisations laid out for volume production must talk, think, and act in terms of daily, even hourly, flow of materials and work throughout the whole organisation. For example, if aero engines are to be produced at the rate of 65 per week with a working week of 130 hours (giving a unit time of two hours per engine) then all stages of production from inward flow of raw materials through machining operations to final completion of the product must support a flow equal to that of unit rate. Actually, the " manufacturing interval " between the receipt of instructions and the commencement of delivery will be controlled by those items which take the maximum fabrication period and, unless steps are taken to avoid it, this manufacturing interval, which is usually a period of six months, or more,

will inevitably recur every time a fresh order is placed. The repercussions of such gaps in output are serious, not only because of the direct loss in products but because of the enormous wastage of productive capacity and the time of skilled labour which is involved in reorganising every detail of the factory because of the interruption of the productive flow.

Reverting to our example of the production of aero engines, it is desirable that the factory concerned should not receive instructions to make, say, 1,000 aero engines but that it should be ordered to proceed with the manufacture of 65 engines per week until further notice. Some guidance, of course, must be given as to the probable total duration of this rate of production.

Supply departments issuing orders on such a scientific basis would be in a position to know at all times the amount of their maximum commitment in raw materials and in components in course of manufacture since the manufacturer concerned would organise his investment in materials and parts in such a way as to support the output of 65 per week. It might be found, for example, that the support of such a production flow would involve a stock of raw materials equivalent to twelve weeks consumption and a stock of components equivalent to eight weeks consumption and the Supply Department concerned would be assured that if immediate cessation of production were at any time needed, these figures would represent the limit of its possible responsibility for incompleted work. Immediate cessation of production is, however, an unlikely contingency since, if new designs are to be introduced, the time taken tooling up will always exceed the time it would take to " work out " stocks of materials and parts from an old design. We append to this memorandum a chart illustrating in a graphic manner how ordering on a fixed batch system so often causes loss of production due to lack of appreciation of the fundamental manufacturing interval which should govern the notice given of continuation, and we strongly recommend that firms handling big volume production should receive instructions in the alternative manner outlined above. We are firmly of the opinion that only by the adoption of this system can raw material supplies, plant availability, and man power be calibrated to give constant delivery of the product at the right time and in the required volume to meet a given programme. At the same time, this system makes available at all times a clear cut picture of the investment in materials and parts in progress so that the effect of any projected increase or decrease in output or even a complete cessation of manufacture can be quickly visualised and steps taken in sufficient time for its liquidation.

THE UNIVERSITY TRAINING OF PRODUCTION ENGINEERS

Paper presented to the Institution, North Eastern and Yorkshire Sections, by Dr. Geo. Schlesinger

Foreword.

The recent establishment of Higher National Certificates in Production Engineering, following strenuous efforts on the part of the Institution of Production Engineers, provides a landmark in the development of technical education in this country. It will take some time for the full effects to become apparent. In the near future, however, we can confidently expect that most of the larger and many of the smaller technical colleges will be offering, as subjects of Higher National Certificate courses, classes in machine tools, jig and tool design, metrology (technical measurement), press and sheet metal work, plastics, welding processes, hot stamping and forging, foundry processes, motion and time study, industrial administration, and production control. The treatment of these subjects will not be such as is required by the craftsman, since he is catered for by City and Guilds courses. They will be designed to meet the needs of future executives. Several such courses are already in existence.

A sound path of development is thus open to the embryo production engineer. He becomes apprenticed to a firm of repute, is given experience in several departments, and as part of his training, attends a technical college on, e.g. one whole day and one, or more, evenings each week. His studies have a direct bearing on the practical work he is doing, they proceed concurrently with the practical work and, if diligently pursued, are rewarded with a certificate of a nationally recognised high value. During the whole course of his training he "belongs" to industry, and is thoroughly saturated in its atmosphere.

Many practical production engineers will feel that no university course can offer a better, or even an equal, method of training than this. The view has its roots in the idea that the student "belongs" to the university and not to industry. He only becomes part of industry at the end of his studies and consequently is at a disadvantage. Dr. Schlesinger's paper, however, shows what has been done to make the university man's contact with industry very close and very real. In fact, his time might be divided equally between the two, an arrangement which provides, at the expense of factory experience, considerably more time for study than is available to the apprentice attending a technical college. It would be a narrow view to condemn this as undesirable.

Leeds, March 14, 1942; Newcastle, September 27, 1941.

At a technical college the part-time students' hours are crammed with work, little or no time is available for quiet thought or helpful discussion, whilst reading and preparation must be done outside working hours. The university student is much better favoured with facilities for broadening the mind by thought, discussion, reading, and preparation:

Some might ask, "How can production engineering be learned except in the engineering shop?"

The function of a university is much wider than merely that of educating such students as happen at any time to be in residence. Its masters and professors are able to devote considerably more time than can technical college lecturers to the development of their subjects, to the sorting of the mass of material called experience to find the basic truths, and to the conduct of research into new fields. If such were done for production engineering it might well be found that many matters could better be presented in the lecture room and laboratory than in the factory. Production engineering offers a vast field for such efforts, a field which will well repay more intensive cultivation. If the universities can be induced to undertake the task amongst the first to benefit would be the technical colleges and they, it must be borne in mind, will probably always carry the major share of the load of actual training.

Perhaps in the not too distant future there will be endowed a chair of production engineering at one or more of our leading universities and inestimable benefit thereby conferred upon industry and the country in general and production engineers in particular.

JAMES FRANCE (*Member*).

WHAT is a production engineer? The *Central Register* says in its statutory order, "A production engineer is a staff engineer who normally holds in any engineering works a position of authority involving responsibility for executive management or control (above the rank of foreman) of any technical function pertaining to production." While all other classes of engineers are organised professionally on a "vertical" basis, according to their own branches of the engineering industry (such as aeronautical, automobile, civil, electrical, gas, locomotive, ship building, mechanical engineering, etc.), production engineers are organised as a "horizontal" basis, since they cover all branches of engineering manufacture.

Basic Training.

What is the best education for a production engineer? Is it possible to train him in schools, colleges, and universities by a definite scheme which, so to speak, cuts horizontally through the various vertical lines of different branches of industry? Of course such an idea is faulty, as faulty as it would be to educate an auto-

mobile, aeronautical, or electrical engineer as such right from his entrance into college or university. Every engineer must have had a general professional training in practice and in theory which for the first two years at least is based upon the general fundamentals of engineering. Only after this foundation is firmly established can the more specialised branches of industry be followed according to the interests and gifts of the young applicant. In the great majority of cases the predilection of the student is firmly settled from the beginning, but his special inclinations are very often radically changed not only regarding the branch of inducting but within this branch concerning the most important decision between designer and production engineer. Designing is an inborn art. Real creative design cannot be learned, and must not be mixed with routine. However, only those designs which can be economically carried out are useful. The machine must not only work satisfactorily according to the inventor's basic idea, but it must also be such that it can be manufactured at a price sufficiently low to ensure sales in a competitive market. Therefore, the first law of production is—*manufacturing begins at the drawing board.* Consequently it is a correct arrangement of all technical schools to compel students to acquire drawing experience and the ability to express ideas in the form of useful drawings. The teacher, however, knowing that pencil lines are not convincing, tries to get a combination between drawing and reality and sends the student to the engineering workshop of the college or the university, where he learns that a lathe turns, a drilling machine drills, another machine mills, grinds, generates, etc. Thus the student acquires a knowledge of the cutting action without acquiring the skill required to operate the machine economically. It would be a waste of time to teach skill on machines which are generally very old.

As the result of an experience of four years as headmaster of the apprentice school in a big machine tool works and of thirty years as professor of production engineering* and machine tools at a leading technical Continental university, the writer is convinced that the education of the successful production engineer must be based on—

(1) A thorough knowledge of design and its preliminary calculations in mechanical engineering.

(2) A practical training in a well-managed workshop equipped with modern machines and tools, divided into—

(*a*) A thorough course of general workshop practice of one to two years (foundry, pattern shop, fitting and erecting, and all important mechanical departments of a well equipped machine shop).

* The production engineering course comprehended: (1) Manufacturing of machines and components, (2) shop management and administration, (3) lay-out of factories, (4) machine tool design.

(*b*) A short course of works administration of about three months comprising the study and application of economic methods of production (planning, rate-fixing, routing, payment, stores, overheads, cost accounting).

University and College Courses.

University or college courses must work in closest connection with the practical requirements. However, they ought to realise the impossibility of giving practical training necessary for modern workshops with equipment which is in very many cases old and obsolete and can never be up to date or comparable with that used in industry. But they can teach the art of planning and rate-fixing applied to the most modern tools and machine tools. In this respect a department for production research of a university led by a professor who is not only following the progress of tool making but leading and pushing it, always using up-to-date equipment acquired by exchanging machine tools and tools at frequent intervals can have great influence on the science of production engineering of a whole country. This training of all those College or university students who feel inclined to become production engineers in their later life ought to be optional in the last year of the ordinary studies. There must be real lectures on production engineering in general and on machine tools in particular. Instead of designing a Diesel engine these candidates ought to have the opportunity to design a machine tool. But all candidates of any branch who are not production minded ought to be compelled to design the complete tooling, jigs and fixtures, small tools, limit gauges with tolerances for some " badly " designed component (their own maybe) of an engine, an electric motor, a locomotive, etc. If they carried out such an exercise for a crankshaft, a rear axle, a motor cylinder block, or a main spindle, etc., they would quickly learn that manufacturing begins at the drawing board.

It might be instructive to review the existing systems for providing a good practical training to *all* students of mechanical and electrical engineering, and give to the would-be production engineer particularly good facilities to widen his experience and knowledge in the field of manufacturing and shop administration.

In the U.S.A. and on the Continent decisive action was taken by two technical universities (Cincinnati and Charlottenburg) some years ago and their arrangements will be described and the results compared with existing British methods.

It is no mere chance that just two *universities* were the pioneers. It corresponds to an old conviction in both countries that all real and lasting progress in technical education is only acceptable after it has been fully tried out for many years at a prominent university. Then the system is universally approved. Before a chair for machine

tool design existed at Charlottenburg, a student could not select a machine tool design course for diploma work in place of the normal heat engines course.

American Practice.

In Cincinnati (Ohio) it was H. Schneider, Dean of the faculty for mechanical engineering, who introduced in 1906 the " co-operative system " between university and industry, eliminating the engineering workshop of universities or colleges as ineffective.

The usual preparation of the Cincinnati university students is at the undergraduate college from the sixteenth to the eighteenth year. Then they remain five years, from eighteen to twenty-three, at the university using the co-operative system with alternate four weeks spent on factory and academic courses. The student in these five years does two years three months in the workshop and offices closely associated with production.

After returning to the university a discussion is arranged there, which is used to clarify all points which the student did not understand, whether in the workshops or in the lectures. This arrangement is very effective, increasing the confidence of the student in both the academic and the practical teacher. It is obvious that a production engineer cannot be better trained to economical thinking than by checking the academic instruction in a real workshop far from the university.

The students are free to select either the " co-operative " or the normal academic course. The " academic students " form the future designers, calculators, etc., and because they are often poorly paid in many industrial countries of the world they form a small minority.

Fig. 1 shows the development of the co-operative system at seven universities and three colleges in the U.S.A. Cincinnati, however, had (in 1922) 100% co-operative students and 208 collaborating firms, but not all of them in Cincinnati ; Boston Tech. 5.5% and only six firms. Success depends on the man ; they had such a man in Cincinnati. Co-operative work, properly carried out, is essential for complete training. The whole organisation and supervision remain completely in the hands of the university. The academic instruction is the basis. If a university of 1,000 students is to collaborate with more than 200 factories of different kinds and be successful, the university must regulate the practical instruction also, otherwise every workshop may introduce another style of education which would disturb the academic progress.

The technical directors of the American factories agreed to this fundamental idea of the Dean and formed a board together with him and accepted his reasonable proposals in their own interest.

Year	University of Akron			Antioch College			University of Cincinnati			Georgia School of Technology			Harvard University			Marquette University			New York University			North-East'n College			Massachusetts Institute of Technology			University of Pittsburgh		
	Sandwich Course	Normal Course	Firms	Sandwich Course	Normal Course	Firms	Sandwich Course	Normal Course	Firms	Sandwich Course	Normal Course	Firms	Sandwich Course	Normal Course	Firms	Sandwich Course	Normal Course	Firms	Sandwich Course	Normal Course	Firms	Sandwich Course	Normal Course	Firms	Sandwich Course	Normal Course	Firms	Sandwich Course	Normal Course	Firms
		No normal course.											For choice of students of all mechanical depts.				No normal course.		Only for mech. engineers.				No normal course.						No normal course.	
1906–07							27	107	15																					
1907–08							61	113	20																					
1908–09							84	106	24																					
1909–10							138	65	28													8		4						
1910–11							176	56	40													30		8				132		7
1911–12							239	48	55													55		8				171		11
1912–13							294	40	68	12	660											70		10				181		16
1913–14							376	30	73	19	712											85		13				249		28
1914–15	30		10				424	34	75	8	724											107		14				255		37
1915–16	43						441	36	82	17	724											143		18				221		39
1916–17	53						473	27	86	18	843											160		27				188		32
1917–18	52						428	25	85	39	945											139		37				172		31
1918–19	132									60	1365					175		11				235		42				180		30
1919–20	134						787	54	135	114	1425	25				215		16				407			57	3078	5	290		28
1920–21	135						950		161	117	1551	25	31	31	15	250		22				592			96	3436	5	322		30
1921–22	141		60	160	49	60	970		208	127	1629	30	17	36	8	312		22	35			800			208	3505	6	334		26

Development of Sandwich courses in some important American Universities.

Fig. 1.—The development of co-operative (Sandwich) against normal courses on ten American colleges and universities.

They understood that they were educating their future employees for their most important positions, such as production manager, works manager, works director, etc., and agreed that it was their duty to make sacrifices.

The board arranged a "co-ordination Faculty" which interviewed the students and put them to the proper vacancies in the workshops. A very experienced professor (who knows every factory and its leading man) does this work and is able to eliminate all personnel difficulties. He has five to six assistants who have only to watch their team of students who work in pairs, one working in the shop, one in the university. Because the distribution of the

University of Pittsburgh
C = College. I = Industry

	1. Year				2. Year				3. Year				4. Year		
	Autumn	Winter	Spring	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter	Spring
Group A	C	C	C	C	I	C	I	C	C	I	C	I	s	C	s
Group B	C	C	C	I	C	I	C	C	I	C	I	s	s	C	s

Harvard Engineering School.

	1. Year Semester		Summer	2. Year Semester		Summer		3. Year Semester				Summer		4. Year Semester	
	I	II		I	II			I		II				I	II
Group A	C	C	Holidays.	C	C	C	s	C	I	C	I	C	I	s	s
Group B	C	C	Holidays.	C	C	s	C	I	C	I	C	I	C	C	C

s = holidays or workshop according to choice

Massachusetts Institute of Technology (Boston Tech.)

	1. Year Course			Summer	2. Year Course			Summer	3. Year Course			Summer	4. Year Course			Summer	5. Year Course		
	I	II	III		I	II	III		I	II	III		I	II	III		I	II	III
Group A	C	C	s		C	C	I	C	I	s	I	s	I	C	I	C	I	C	C
Group B	C	C	C		C	C	C	I	C	I	C	I	s	I	s	I	C	I	s

DISTRIBUTION OF SANDWICH COURSES IN THREE UNIVERSITIES.

Fig. 2.—Sandwich system at Pittsburgh, Harvard, Massachusetts Technical Universities.

Cincinnati students is made in Cincinnati, Cleveland, Chicago, Boston, etc., up to fifteen hours in the train from Cincinnati are sometimes necessary to make the survey effective. However, where there's a will, there's a way! The intelligent, diligent, and honest graduate is always sure of a post in the factory where he did his practical course. Personal records are used both by the firms and the university. They are exchanged, and give a good indication of the value of the man in question (at the end of his studies). In all cases the students are paid in the workshop from 30 cents to 50 cents an hour, depending on their efficiency. The students generally remain during one year in the same factory and only change places every four weeks. Up to 90% of the graduates kept the profession which they selected after the second year. The Cincinnati professor says that the foremen learn very quickly to fill in these reports correctly and learn to characterise these students with good human understanding.

The total time per year is eleven months, fifty-five months in five

years—not much time for vacations. The directors of the works were enthusiastic for the system in Cincinnati.

Fig. 2 shows that the functioning of the co-operative plan differs considerably, depending on the university and industry.* Pittsburgh begins in the second year and ends in the third, with altogether

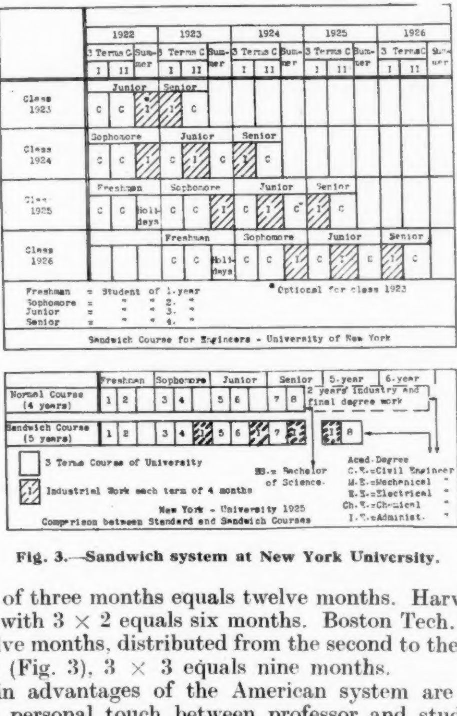


Fig. 3.—Sandwich system at New York University.

four terms of three months equals twelve months. Harvard in the third year with 3×2 equals six months. Boston Tech. has 6×2 equals twelve months, distributed from the second to the fifth year. New York (Fig. 3), 3×3 equals nine months.

The main advantages of the American system are: (1) The permanent personal touch between professor and students. (2) The continuous assistance of the students in their exercises, made possible by the great number of assistants (one assistant to every eight or ten students). (3) The high quality of the equipment of laboratories and research departments. (4) The collaboration between college or university and workshop (the combination of academic and practical instruction resulting in superior production engineers, educated in the real workshop atmosphere among most modern tools and machines). (5) The education of groups of engin-

* The data, however, were collected in 1924.

eers who do not design or manufacture but are prepared for shop administration and management (planning, rate-fixing, routing, accounting). (6) The permeation of the whole academic studies with thinking in terms of economics. The best form of instruction on economics is to work among workmen and foremen, for all of whom time is money.

Continental Practice.

The *Continental* plan is constructed differently. It was not possible to arrange Sandwich courses between university and college. However, one year of practical work is compulsory, half of which is usually carried out *before* commencing the course of studies at the university.

The practical year is watched by an ordinary professor—" the apprentice's father "—at each technical university. The student must have matriculated before he begins to work. Therefore he belongs to the university and has to report to his faculty during his stay in industry. Engineering workshops do not exist in universities or colleges. Collaboration with industry is satisfactory but not so intimate as in U.S.A. The academic courses last four years (of thirty weeks). Twenty-two weeks are holidays or vacations. Generally two times thirteen weeks in two years are used for practical work during the long summer vacations so that twenty-six weeks before beginning and twenty-six weeks during the courses give fifty-two weeks practical work in a factory approved by the university. Four and a half years are the minimum time of studies including workshop practice, then follow three months for the big diploma work.

All students of mechanical and electrical engineering were obliged to hear the lectures and to work the exercises on production engineering in the fourth year of studies. The lectures have 30 × 2 equals sixty hours per year, the exercises 30 × 2 equals sixty hours oral seminary, i.e. discussion between professor and students on shop management, rate-fixing, and tooling, and about 30 × 2 equals sixty hours for design of tools, jigs, and fixtures or of a machine tool. These 180 hours naturally form a strong foundation for the general understanding of manufacturing problems. Those who select production engineering as a main examination subject must make a design of a complete machine tool (sixty to a hundred hours), hear the lectures on machine tools (2 × 30 equals sixty hours), and take part in organised discussion under the supervision of the professor (2 × 30 equals sixty hours). Further, they can, if they choose, work for a minimum of half a year, to a maximum of two years in the production research department investigating tools, machine tools, and measuring equipment (8 × 15 equals 120 hours per semester, or 240 hours per one year). These well

informed graduates are easily taken by the very important German machine tool industry (80,000 workmen to-day).

Examples of Practical Work.

It may be useful to show by example how this academic education of production engineers was really made. The fundamental idea was, as mentioned above, that production begins on the drawing board. The designer must have practical and thorough experience. He must know the possibilities of the workshop—must know the details of the physical properties of the material, tensile strength, Brinell hardness, resistance against stress, strain, impact, fatigue, etc. He must comprehend the problem as a whole and not lose himself in detail. The design is different from the drawing for the pattern shop, which is generally made by the pattern maker himself, and this intermediate drawing must take care of foundry practice. It is therefore a good scheme to have the professional engineer apprentice working for some time in the foundry, before he goes to the pattern shop. The simple lever (Fig. 4) without cores needs two boxes. The quadrant (Fig. 5) needs simple cores and two flasks. The very simple-looking double-seat valve (Fig. 6) needs three flasks and a core box, and requires the most expensive work in the foundry. This leads on to planning. The people in the planning department make the operation plans. They have very good experience of finding the simplest way of manufacturing for a given workshop. It is a good scheme to show them the drawing in pencil before it is traced and printed. Generally the designer is more easily persuaded to make changes as long as the drawing is made in pencil, but if all is traced, copied and made ready for purchase of material, the tendency to object to changes of the designer is understandable. Planning requires the capability of thinking before the piece is made, of seeing all operations in the imagination. Fig. 7 shows the twenty-four operations for a rear axle of a motor car with the general lay-out of tools, jigs, and fixtures. The tooling-up demands in all cases an understanding of the design and experience in the workshop.

Take the aluminium piston of an engine as an example. It is already turned externally and the gudgeon pin holes are bored. Now the internal surfaces for the connecting rod must be milled parallel to the axis of the piston and perpendicular to the gudgeon pin axis.

Fig. 8 shows the milling attachment which allows the facing cutters to enter into the bore of the piston. Fig. 9 shows a revolving fixture. One side is set up with the piston, the other side is empty, to be filled by the same operator. The caption explains how the piece is located. It is a study in itself to develop the correct clamping fixtures which depend on the shape of the piece, on the cutting action, and the forces which must act on the piece. In quantity manufacturing the necessity to clamp pieces which are interchange-

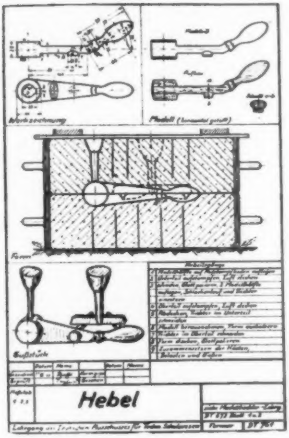


Fig. 4.—Simple casting, lever.

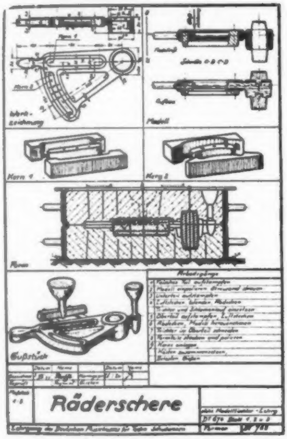


Fig. 5.—Casting with quadrant cores

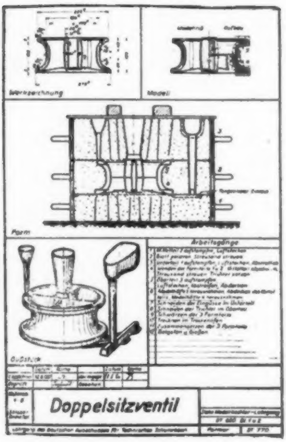


Fig. 6.—Three-part mould for a double-seated valve.

TRANSLATION OF GERMAN TITLES OF FIG. 4.

Werkzeichung = working drawing.
Modellriss = pattern sketch.
Aufbau = construction sketch.
Modell (horizontal geteilt) = pattern divided horizontally.
Schnitt = cross section.
Form = mould.
Gusstueck = casting.
Massstab = scale.
Hebel = lever.
Raederschere = quadrant (box of 2 parts and cores).
Doppelsitzventil = double seat valve (box consisting of three parts).

Arbeitsgaenge = operations

(1) Lay half pattern to stamping board.
(2) Ram lower mould of pattern ; vent.
(3) Turn over the box, smoothing, put on second half pattern, insert riser and gate.
(4) Ram upper mould, vent.
(5) Cover; cut runners in lower mould.
(6) Remove pattern ; repair mould.
(7) Cut runners in upper mould.
(8) Dusting the mould ; smoothing.
(9) Assembly of upper and lower box. Load and cast.
Hebel = lever.

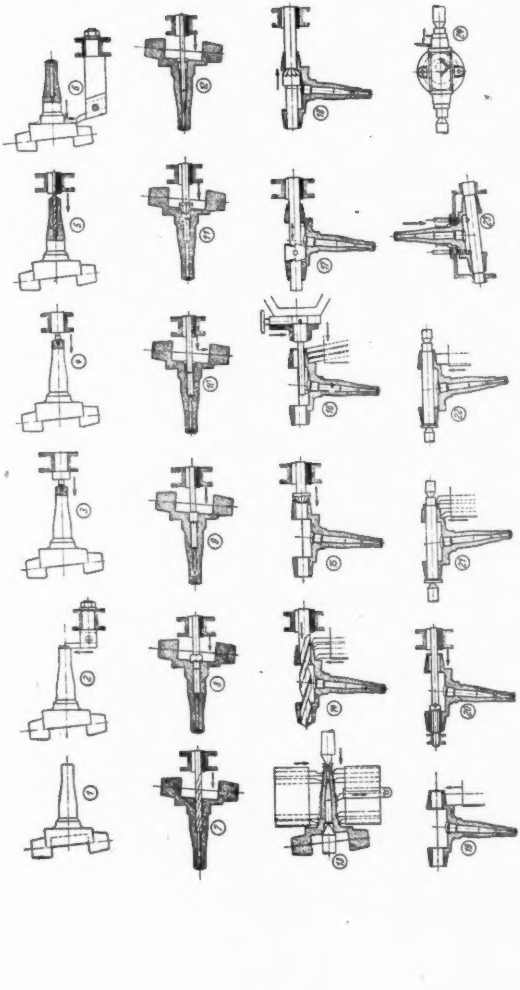
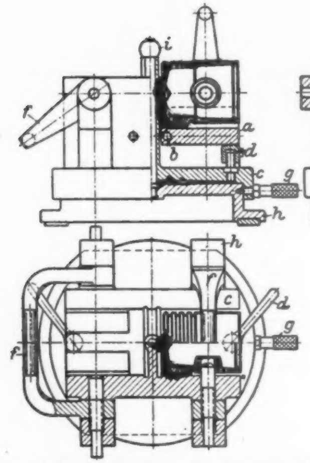


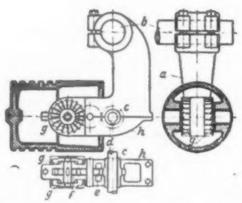
Fig. 7.—Planning of a rear axle of a motor car.



Revolving Fixtures for two pistons. One being machined, the other loaded.

a locating and clamping vice. b pivot for adjustment of a, c turntable of fixture, d lifting nut to align piston with e_1-e_2, thrust bolts (multistart threads, right and left hand), f double nut with handle for e_1 and e_2, g locating pin with handle to swivel the turntable c and to lock it to h baseplate, i tightening nut to lock c with h.

Fig. 9.—Revolving jig piston (boring jig for piston).



Milling Fixture for Facing Internal Surfaces of Gudgeon Pin Bosses.

a body of fixture fastened on b overhanging arm, c spur gear on main spindle d, e,f, spur gear drive of milling cutter, h bottom frame of fixture.

Fig. 8.—Milling jig for piston.

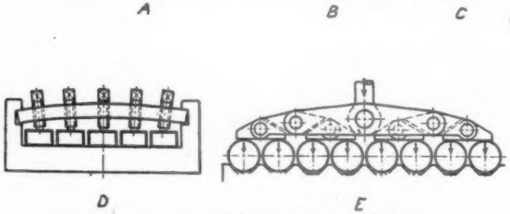


Fig. 10.—Correct and incorrect clamping device.

able but have not absolutely the same diameter demands special arrangements. Fig. 10 A-D shows on the top simple pieces which have two parallel surfaces. For the small distances (B, C) an equalising lever actuated by a ball (C) is sufficient. For the big distance where the clamping must be done exactly above the supporting surfaces a pivoted lever (A) is preferable. The two illustrations on the bottom show how five pieces are clamped, each single by five

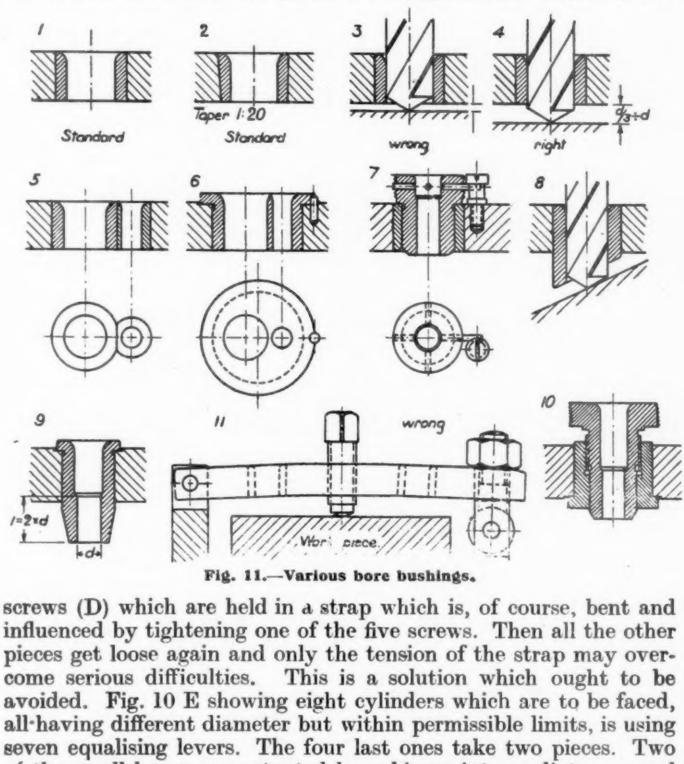


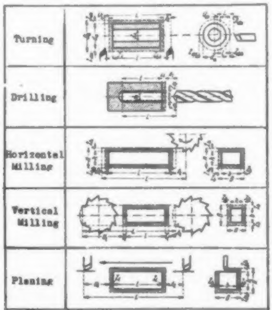
Fig. 11.—Various bore bushings.

screws (D) which are held in a strap which is, of course, bent and influenced by tightening one of the five screws. Then all the other pieces get loose again and only the tension of the strap may overcome serious difficulties. This is a solution which ought to be avoided. Fig. 10 E showing eight cylinders which are to be faced, all having different diameter but within permissible limits, is using seven equalising levers. The four last ones take two pieces. Two of the small levers are actuated by a bigger intermediate one and finally all the six pivots are supported in the main lever which is pressed down by a central pressing bar. By this design the unavoidable differences in diameter within the permissible tolerances are overcome.

The system to compare right and wrong solutions of the same problem is very useful for the lectures on correct design of jigs and

fixtures. The drill must be guided. It may bore against a horizontal or an inclined surface and the clamping of the piece and the guidance bushings for the drill must not be combined in the same strap. (Fig. 11).

Experience proved that even the best and most thorough explanation in the lecture room is not sufficient to introduce the student into the correct design of jigs and fixtures. He must design them himself on the drawing board and it is the duty of the teacher to select such pieces which are characteristic for the purpose of jig



Surplus = Z Start = A Overun = U

Calculation Scale	Abbreviation	Dimensions contain following values			
		Drawing Size	Machining Allowance	Start	Overun
Length	L	l	$2 \cdot Z_l$	A_l	U_l
Width	B	b	$2 \cdot Z_b$	A_b	U_b
Height	H	h	$2 \cdot Z_h$	A_h	U_h
Outside ∅	De	d_e	$2 \cdot Z_{de}$	A_{de}	U_{de}
Bore ∅	D_i	d_i	$2 \cdot Z_{di}$	A_{di}	U_{di}

Machining Allowances

Fig. 12.—Material allowance and machining operations.

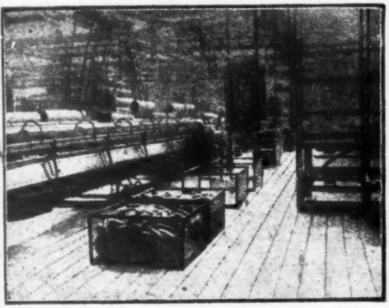
making. There are so many examples that there will never be a standardisation of typical designs which would kill the initiative of the student. The best way is to take a finished drawing made by the student himself in the third or fourth year, pick out from this drawing one piece which is obviously wrongly designed, or if the design is fairly good, to pick out one characteristic piece and have the tools, jigs, fixtures, and gauges made by the student as a practical criticism of his own design. This gives him a stimulant to design correctly for production.

Material and Transport.

The next step is to master the *material and transport problem*, which represents in all workshops a very essential part of manufacturing. The material allowance is dependent on the machining operation (Fig. 12). This allowance depends both on the dimensions

A. Old racks. Wooden boxes, worn cane baskets. Introduction of the first iron containers.

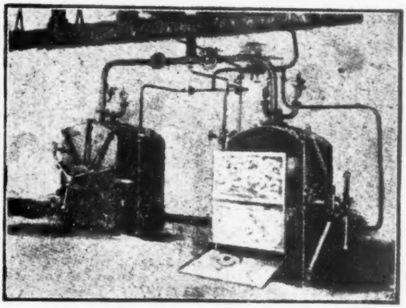
B. View of the new yarn store, low and high stacks.



C. Container with yarn charge before the self-acting mule.

D. Container on the balance. (Constant tare).

E. Storekeeper stacking full containers.



F. Containers in steam apparatus. Closed (left). Opened (right).

Fig. 13.—The old disorderly store for bobbins and the new arrangement by the standardised transport containers.

of the raw materials which can be delivered (black or bright, pre-finished or rough) and its preliminary state. They decide the dimensions to be ordered. The losses by too much material allowance are in some cases very great. They may kill the possibility of profits if competitors can work with smaller material allowances. The designing office and the purchase department must be in close touch regarding this first stage of production. When the material enters the works a much bigger problem is to be solved, that is the transport of the material without detours and with a minimum of transporters through the different workshops from the yard or the storeroom to the inspection room of the despatch department.

We will take as an example a textile shop which is spinning the bobbin from the rough cotton or wool, storing it, steaming it, and weighing it several times until the container with the necessary amount of bobbins is transported to the loom for weaving the tissue. Fig. 13 shows at *A*, the old disorderly storeroom with damaged containers of wood or cane which changed their weight on account of wear and the moisture always present in the air. They are heavier on rainy days and lighter on hot and dry summer days, consequently the tare must be taken on each balance before the container is filled and checked afterwards, because the contents are very expensive and precious, and the tare is generally much bigger (22 lb.) than the weight of the contents (6 lb.). Consequently this is very important for controlling the output. Then the basket arrives in the storeroom and its contents are transferred from the container to the shelves. It must be handled by taking it out, handled for the second time by packing it into the container, handled again in transporting it to the steam apparatus for the warp mill and back again to the storeroom and finally to the loom. This problem has been solved in the following way. Wooden or cane baskets are replaced by welded, square containers, *B* to *F*, the walls of which are formed by open net work. The shape of the bottom and the top of the iron frame is standardised so that the bottom fits to the next one and so on. Therefore, the solid wooden shelf is replaced by the transportable containers. Putting one container above the other, *B*, *E*, the shelf is made automatically of different heights up to about six to seven containers in one vertical row. The steaming apparatus, *F*, is made so that two containers together can be pushed into the steaming room and taken out afterwards without touching the contents. Now the steamed bobbins may be transported either back to the storeroom or to the warping mill or loom. The idea is, from the self-actor, *C*, to the storeroom, from the storeroom, *E*, to the steaming apparatus, *F*, from the steaming apparatus to the warping mill or the loom, nobody has to touch the sensitive bobbins. They are visible on account of the network in the walls. The storeroom is always in order and requires the attention of only one man or one strong

woman who is able to take the filled container (30 lb.) to its place. There is no changing of the bobbins which belong together, made as one charge of the self-actor, *C*. No change of tare, *D*, because the iron frame does not wear perceptibly for many years, does not change its weight on account of the weather, so all the containers can have the same weight. They are calibrated for that. It is easy with iron but impossible with wood. Now the scale for the weights and the balance can have added that constant tare weight once and for all and the weights give directly the contents disregarding the tare. This is a very good example to solve the transport problem in a particular shop on quantity production. One single handling, no change during storing and transporting. One storekeeper hand-

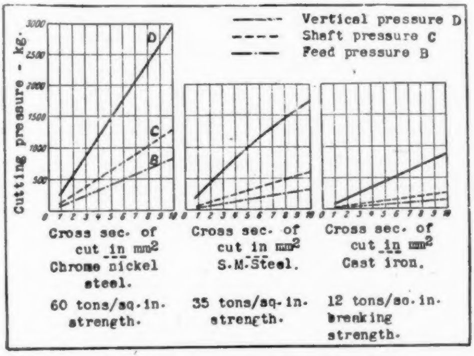


Fig. 14.—Cutting pressure on turning.

ling full containers instead of two to four women, who sort permanently. In this special case another advantage was gained because the open-sided containers permit ventilation which kills the moths, and in that case the moth is the greatest enemy of cotton and wool. Further, the colours are to be seen, if it is white, yellow, green, or black yarn, and a shield on the basket shows when it was made and which of these baskets belong together to secure the uniformity of the cloth. This is the technical task to solve correctly material problems which may be decisive for the economy of the whole workshop.

The Machining Problem.

The next is the *machining problem*. This begins with the machine tool. The power of the machine tool ought to be fully utilised. This can be done by selecting the right chip area (depth by feed) and the highest permissible speed, depending on the material. It is not possible to exploit the same machine if it is used for cast iron, mild steel, and hard Cr-Ni steel (Fig. 14). Hard and resistant

STANDARDISATION OF SPEEDS. (revs/min)

Series 1,06 (R40)	Series 1,12 (R20)	Ser. 1,26 (R10)	Ser. 1,58 (R5)	Ser. 1,19 ($\sqrt[4]{2}$)	Ser. 1,41 ($\sqrt{2}$)	Series 2 (2)
0,118	0,118	0,118	0,118			
0,125						
0,132	0,132			0,132	0,132	
0,140						
0.150	0,150	0,150				
0,160				0,16		
0,170	0,17					
0,180						
0,190	0,19	0,19	0,19	0,19	0.19	0.19
0,200						
0,212	0,212					
0,224				0,224		
0,236	0,236	0,236				
0,250						
0,265	0,265			0,265	0.265	
0,280						
0,300	0.30	0,30	0,30			
0,315				0.315		
0.335	0.335					
0.355						
0,375	0.375	0.375		0,375	0.375	0.375
0,400						
0,425	0.425					
0,450				0.45		
0,475	0,475	0,475	0,475			
0,500						
0,530	0,53			0.53	0.53	
0,560						
0,600	0.60	0,60				
0.630				0,63		
0,670	0,67					
0,710						
0,750	0,75	0.75	0.75	0.75	0,75	0,75
0,800						
0,850	0.85					
0,900				0.90		
0,950	0.95	0.95				
1,000						
1,060	1.06			1,06	1,06	
1,120						

Ser. 1,06 (R40)	Ser. 1,12 (R20)	Ser. 1,26 (R10)	Ser. 1,58 (R5)	Ser. 1,19 ($\sqrt[4]{2}$)	Ser. 1,41 ($\sqrt{2}$)	Series 2 (2)
1,18	1,18	1,18	1,18			
1,25				1,26		
1,32	1,32					
1,40						
1,50	1,50	1.50		1.50	1,50	1.50
1,60						
1,70	1,7					
1,80				1,8		
1,90	1,9	1,9	1,9			
2,00						
2,12	2,12			2,12	2,12	
2,24						
2,36	2,36	2,36				
2,50				2,5		
2,65	2,65					
2,80						
3,00	3,0	3,0	3,0	3,0	3,0	3,0
3,15						
3,35	3,35					
3,55				3,55		
3,75	3,75	3,75				
4,00						
4,25	4,26			4,25	4,25	
4,50						
4,75	4,76	4,75	4,75			
5,00				5,0		
5,30	5,3					
5,60						
6,00	6,0	6,0		6,0	6,0	6,0
6,30						
6,70	6,7					
7,10				7,1		
7,50	7,5	7,5	7,5			
8,00						
8,50	8,5			8,6	8,5	
9,00						
9,50	9,5	9,5				
10,00				10,0		
10,60	10,6					
11,20						

Ser. 1,06 (R40)	Ser. 1,12 (R20)	Ser. 1,26 (R10)	Ser. 1,58 (R5)	Ser. 1,19 ($\sqrt[4]{2}$)	Ser. 1,41 ($\sqrt{2}$)	Series 2 (2)
11,8	11.8	11,8	11,8	11,8	11,8	11,8
12,5						
13,2	13.2					
14,0				14,0		
15,0	15.0	15,0				
16,0						
17,0	17			17	17	
18,0						
19,0	19	19	19			
20,0				20		
21,2	21,2					
22,4						
23,6	23.6	23,6		23,6	23,6	23,6
25,0						
26,5	26,5					
28,0				28		
30,0	30	30	30			
31,5						
33,5	33.5			33,5	33.5	
35,5						
37,6	37.5	37.5				
40,0				40		
42,5	42,5					
45,0						
47,5	47,5	47.5	47.5	47.5	47.5	47.5
50,0						
53,0	53					
56,0				56		
60,0	60	60				
63,0						
67,0	67			67	67	
71,0						
75,0	75	75	75			
80,0				80		
85,0	85					
90,0						
95,0	95	95		95	95	95
100,0						
106,0	106					
112,0				112		

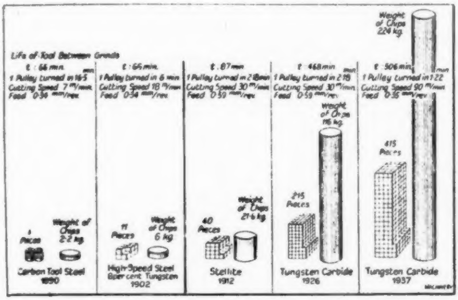
Ser. 1,06 (R40)	Ser. 1,12 (R20)	Ser. 1,26 (R10)	Ser. 1,58 (R5)	Ser. 1,19 ($\sqrt[4]{2}$)	Ser. 1,41 ($\sqrt{2}$)	Series 2 (2)
118	118	118	118			
125						
132	132			132	132	
140						
150	150	150				
160				160		
170	170					
180						
190	190	190	190	190	190	190
200						
212	212					
224				224		
236	236	236				
250						
265	265			265	265	
280						
300	300	300	300			
315				315		
335	335					
355						
375	376	375		375	375	375
400						
425	425					
450				450		
475	475	475	475			
500						
530	530			530	530	
560						
600	600	600				
630				630		
670	670					
710						
750	750	750	750	750	750	750
800						
850	850					
900				900		
950	950	950				
1000						
1060	1060			1060	1060	
1120						

Ser. 1,06 (R40)	Ser. 1,12 (R20)	Ser. 1,26 (R10)	Ser. 1,58 (R5)	Ser. 1,19 ($\sqrt[4]{2}$)	Ser. 1,41 ($\sqrt{2}$)	Series 2 (2)
1180	1180	1180	1180			
1250				1250		
1320	1320					
1400						
1500	1500	1500		1500	1500	1500
1600						
1700	1700					
1800				1800		
1900	1900	1900	1900			
2000						
2120	2120			2120	2120	
2240						
2360	2360	2360				
2500				2500		
2650	2650					
2800						
3000	3000	3000	3000	3000	3000	3000
3150						
3350	3350					
3550				3650		
3750	3750	3750				
4000						
4250	4250			4250	4250	
4500						
4750	4760	4750	4760			
5000				5000		
5300	5300					
5600						
6000	6000	6000		6000	6000	6000
6300						
6700	6700					
7100				7100		
7500	7500	7500	7500			
8000						
8500	8500			8500	8500	
9000						
9500	9500	9500				
10000				1000		
10600						
11200						

Fig. 15.—Standardisation of speeds and feeds for machine tools.

materials need more power than soft ones. Adapting and sorting machine tools of different strengths to the most suitable material is of importance to the production engineer. At the same time it segregates different types of swarf and sorted swarf increases automatically the value of the chips. If a Cr-Ni steel is mixed with mild steel, with cast iron, or even with copper it is useless for Cr-Ni production. The mixed chips can only be used for inferior material. Brass, copper, and aluminium are very expensive materials, and so is Cr-Ni steel. It pays to think of reserving the different machines for different materials.

Exploiting power and speed of the machine tools is the next production problem. If the machine has not power together with high speeds we cannot use cemented carbides. Consequently, the standardisation of speeds and feeds (Fig. 15) at least for the different groups of machine



Diagrams Illustrating the Increase in the Efficiency of Cutting Tools Between 1890 and 1937. The Work Involved is the Turning of Cast-iron Pulleys 4½ inches in diameter by 4 inches face width, the Material having a Tensile Strength of 11.5 tons per Square Inch and a Brinell Hardness of 170

Fig. 16.—Development of tools from 1890 to 1937 and their economic affect.

tools (lathes, drilling, milling, grinding machines) is a necessity. It allows to the machine tool designer only the use of *preferred numbers*. These preferred numbers involve the geometric series with standardised common ratios—altogether six. The basis is the $\sqrt[10]{10}$ equals $\sqrt[3]{2}$ equals 1.26. These preferred numbers contain the metric unit 10 and the inch unit 2, decimal and halving. The table is made up from .118 revolutions to 11,200 revolutions, and is valid for almost all machine tools, with the exception of the quickest running machines above 11,000. It contains all necessary possibilities of the whole machine tool branch. Proof of its value is that the whole Continent, Scandinavia, *Russia*, Italy, Japan, and partly the United States use these standard figures for speeds and feeds with a great success for the workshop and for the rate-fixing

department. They have not a big index with 100, 200, or more date charts for each machine tool, but one chart for each group. In this country the rate-fixer has no possibility to set the speeds correctly if every lathe of, e.g. the 40 in the workshop has a different series of speeds. There operator, foreman, rate-fixer have the same

COST COMPARISONS FOR OLD AND NEW MACHINES

A—Cost Comparison (excluding Material)

	Old Machine	*New Machine*
Value of old machine	s.3,860	s.15,400
Production time per piece ...	min. 30	min. 15
Machine life	years 10	years 5
Wage rate	s.1.50	s.1.64
Overhead cost per cent.	150	160

Old Machine	New Machine
Labour costs for 30 min. (at s.1.50 per hour) s.0.75. Depreciation of machine per piece: Book value s.3,860. 10 years of 50 weeks of 48 hours = 24,000 hours. $\frac{3,860}{24,000}$ = s.0.161 per hour, thus for ½ hour, s.0.08. Overheads 150% on labour costs (= s.0.75) s.1.13.	Labour costs for 15 min. (at s.1.64 per hour) s.0.41. Depreciation per piece: Value of new machine = s.15,400. 5 years of 50 weeks of 48 hours = 12,000 hours $\frac{15,400}{12,000}$ = s.1.29 per hour, thus for ¼ hour s.0.32. Overheads 160% on labour costs (= s.0.41) s.0.66.
Cost per piece, s.1.96.	s.1.39 Reduction 29.2% = + 0.57 (Compared with 1.96) s.1.96

Fig. 17.—Cost comparisons for old and new machines.

uniform basis, which facilitates the work enormously. Now it is easy to decide which kind of cutting tool is best for a particular kind of application—carbon steel, high speed, super high speed, stellite, cemented carbide tools. The advantage of the better tool is clearly shown in Fig. 16. As most workshops have a mixture of very old, old, fairly new, and most modern machines, the smallest part belongs to the most modern machines, it is now easy to decide "When is a machine tool old?" This is always the case when a modern machine tool permits to manufacture cheaper than the existing machine tool. (Fig. 17). The economic point of view is decisive and this can easily be proved by the actual result. The factory costs of each part depend on the material plus wages plus overheads. The ratio between those three basic expenses changes with the different branches of manufacturing. The factory costs of machine tools, fittings, instruments, apparatus, clocks and watches, railway passenger cars and trucks, Diesel engines, lorries are compared in Fig. 18.

The amount of materials, the amount of wages, and the ratio between overheads and wages, all three are so different in the different branches that they must be controlled in detail, particularly

	Machine Tools					
	Medium heavy		Heavy			
	A	B	C	D	E	F
Material	31.8	41.2	48.4	51	48	32.7
Wages(productive)	20.7	18.3	16.1	12	13.5	15.8
Overheads	47.5	40.5	35.5	37	38.5	51.5
Manufacturing cost	100	100	100	100	100	100
$\frac{\text{Overheads}}{\text{Wages}} \times 100$	230	220	220	308	285	325

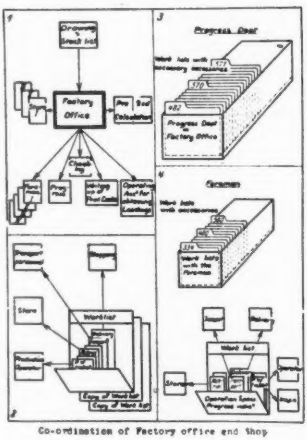
	Metal goods			Clocks	Railway truck construction		Diesel engines	Lorries
	Fittings	Drawing Instruments	Brass apparatus		Passenger	Goods		
Material	30	19	37	44.5	55	67	44	68
Wages(productive)	25	28	21	21.5	18	10	14	10
Overheads	45	53	42	34	27	23	42	22
Manufacturing cost	100	100	100	100	100	100	100	100
$\frac{\text{Overheads}}{\text{Wages}} \times 100$	180	190	200	158	150	230	300	220

Percentage ratio of Material, Wages and Overheads in Manufacturing Costs.

Fig. 18.

the overhead expense is in all cases more than the wages. They ought to be watched very carefully and the only way to find correct selling prices is to control the overhead expense per department by bookkeeping. This is the biggest and most difficult problem. However, its fundamentals can be taught to the professional engineer.

But first of all this apprentice must know how modern production



Co-ordination of Factory office and Shop

Fig. 19.—Co-ordination of factory, office and shop.

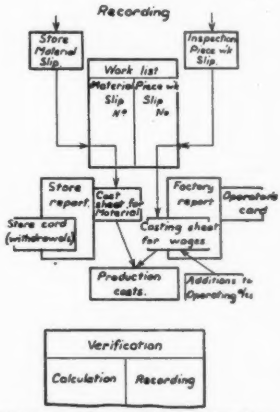


Diagram of positive recording of Material and Wages.

Fig. 20.

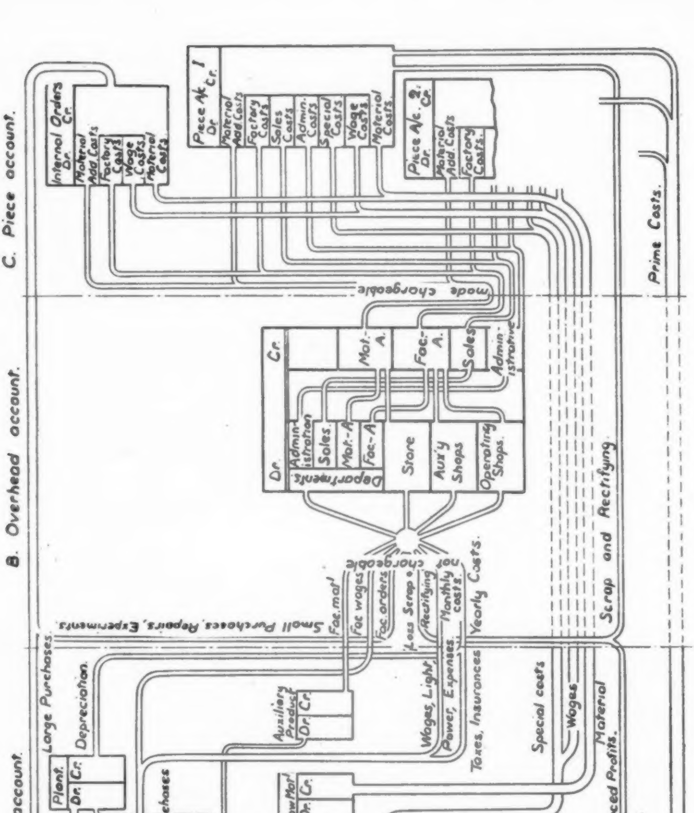


Fig. 21.—Connection between capital, overhead and piece accounts.

is done and this cannot be learned in apprentice workshops of a college or university. They may be well fitted with modern machines to-day or may have after some decades a very good teaching reputation, but nevertheless obsolete workshops. It is not possible to follow with the equipment of the university the modern development of machine tools machining stronger and harder materials. Therefore, there must be intimate co-operation between industry and college. The best example is the development of this system in the U.S.A. described above. (See Fig. 1).

Management Practice.

The last point is: is it possible to give the young professional engineer of university or college a realistic review of the management practice of the works in which he is educated? No doubt, the college and university can prepare the student, can have lecture, on the determination and the use of material, wage, overheads expense, and industrial cost finding. They can give an insight into

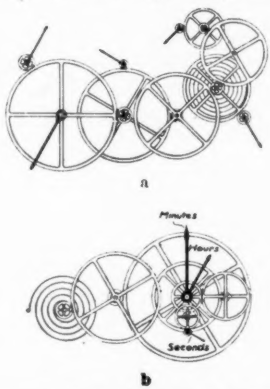


Fig. 22.—Schematic comparison of rendering of disconnected reports (a) with a positive motion of manufacture (b).

these very important offices. How the work is prepared in the factory office for the progress department and for the works manager, and realised by the foreman is shown in Fig. 19.

The diagram Fig. 20 shows the compulsory recording of material and wages to the order sheet (by double entries). Diagram 21 shows the connection between capital, overhead, and piece accounts, and the unity between the preparation of the work, the management of production, and its control by the cost accounting. The student must be taught that statistics are arbitrarily collected reports made from more or less uncontrolled information which ought to be

replaced by a positive motion of manufacture which is secured and automatically done only by the accountant but adapted to technical intelligence (Fig. 22a, b). The actual work of the production engineer and its control by the accountant must be organised like the work of two brothers who have the same aim—the prosperity of their business. The writer found by the personal contact with the students of all ages (from twenty to sixty) that the practical performance of shop administration problems made with all necessary mechanical means in the lecture hall was the most attractive course for an audience of 400 to 500 students during thirty years of teaching.

British Universities.

British education of production engineers by universities and colleges is not organised on uniform lines. Some universities and colleges have machine shops which are used to replace the necessary industrial education, but there is practically no training directed specifically for the preparation of production engineers. The practical work which the students are compelled to carry out in these workshops is principally of a rough informatory character. In particular they miss the indispensable economical side of workshop practice. The technical staff of foremen and skilled operators is generally reduced to the utmost minimum—when they are only teaching—and they have not sufficient time for a good instruction of the large number of students which are present at one time, if the college workshops are occupied with responsible work for external clients.

London, Cambridge, and other universities occupy their students usually for a period of approximately one day a week extending over the first one or two years of the university course. The equipment of these workshops is in general, with few exceptions, obsolete.

Visits to one university workshop in the steel centre of Great Britain for instruction only and one of a college of high reputation had the amazing result that in the first machine tools up to forty years old were used and in the latter ten to fifteen modern machines were mixed with the great bulk of machines made between 1915 to 1920. Practically no cemented carbide tipped tools, and only a few super-rapid tools (tungsten-cobalt-molybdenum) were in use. In their places were the ordinary high speed tools with 18% W and carbon steel, e.g., an instruction sheet on the wall stated that the top rake angles should vary between 0° and 40° without reference to the material.

No particular theoretical training for production engineering is included in the syllabus of London and Cambridge. In the case of Cambridge University the engineering course (mechanical sciences) extends over a period of three to four years, and it is generally

expected that a student who intends to work in the field of production engineering will undergo a post-graduate apprenticeship on leaving Cambridge in order to fit him for the particular branch of industry in which he intends to work. It appears that the authorities responsible for drafting the course at the university set out to give students a thorough grounding in the general principles of engineering together with a sound knowledge of mathematics and sufficient practical training to enable them to understand the processes involved. Thus practical training in the machine shop is no more extensive than the practical training given in special subjects such as surveying, heat engines, electricity, etc.

Most British universities have three terms each year and this leaves a very long summer vacation. In the case of Cambridge seventeen weeks. Engineering students are encouraged to go to reputable firms to get practical experience but this arrangement is extremely loose, there being no compulsion whatsoever. The usual procedure is for the university to put up a list of vacancies just before the summer vacation and the students apply for these vacation posts from the university. Such arrangements are not specially confined to engineering workshop practice. Similar arrangements exist between shipping companies and the universities which enable students to travel during vacations.

In Edinburgh University students following the mechanical or electrical course may eventually become engaged in production engineering, but the former is preferable for a student who intends from the first to fit himself for such work.

The long vacation of sixteen weeks per year is nominally used for working for the first and second year degree exams. in September, but most students arrange to get practical experience also. They are assisted in this by a system of " exemptions " whereby students obtaining a certain standard in the end-of-term exams. are exempted from the corresponding degree exams. Most students get at least some exemptions, and a good many may get it in all subjects. So that he is totally free to devote all his time to practical work. The university authorities takes conside, able trouble in helping students to obtain this work.

The University College (Nottingham) offers its full-time students Sandwich courses in conjunction with selected forms. Particulars of these courses are as follows.

A comprehensive course combining theoretical and practical training, known as a Sandwich course may be taken by students reading for a diploma or a degree in engineering. Many firms prefer candidates for appointment who have taken this type of training and the course is suitable either for students coming to the college direct from school or for apprentices and pupils who have already

begun their works training. In the degree course such students leaving college have a year of practical training, after passing the intermediate examination, and if they wish, take a similar year of practical work after passing Part I of the final examination, returning to college for one year to prepare for Part II. The Sandwich course for the diploma extends over four years. Students attend full time for the first year, and in the second, third, and fourth years spend six months (October to March) at the college and the remainder of the year in works.

Apart from the universities a number of technical colleges give theoretical training to trade apprentices. One standard examination which covers a number of the subjects in the field of practical production engineering is the City and Guilds machinists', turners', and fitters', examination, particulars of which are as follows: (1) Workshop science and technique, (2) drawing and calculation. Both items and the final examination include materials, metals and alloys, heat and heat treatment, primary forming processes (foundry, forge), heavy works, shop mechanics and friction, cutting tools, fitting and erecting, measurement and gauging, tooling, tool room work, jigs and fixtures, sequence and planning, lubrication, lubricants and coolants, safety measures.

There are various schemes of the kind in different parts of the country. Two of them—those of the Imperial College Union and the City and Guilds Union—have been merged tentatively during the session 1940. The seventh annual report shows considerable progress in several directions. The number of students taking part has now reached nearly 300.

The report contains quotations from reports made by various engineering firms assisting in the scheme, and these indicate that the arrangement is often of mutual benefit, the firms gaining useful services in return for the wages and experience given.

The names of the 126 engineering firms assisting the scheme by taking students during the vacations are given in this report.

A very useful voluntary collaboration exists, e.g. between the City College of Coventry and thirty of the most important firms in this city. Its object is to provide for boys an opportunity to secure the thorough training and education that is necessary for them to become craftsmen and/or to hold positions of responsibility on the executive or technical staffs. A similar elastic arrangement exists between Derby Technical College and the important industrial firms of this town. The classes are generally held one whole day and two evenings per week during the sessions. There are definitely a good many schemes, all of which the writer could of course not study.

In some cases it is the managements of the great British industrial works which have taken the initiative to improve the education of

the young engineer for the purpose of production. I mention Leyland Motors, Ltd. (Leyland), Birmingham Small Arms (Birmingham), Brush Electrical Engineering (Loughborough), Metropolitan Vickers (Trafford Park, Manchester).

Let me finish this by no means exhaustive study by describing the methods of training production apprentices of this big concern, which shows in its education booklet* some British universities (Cambridge, Oxford, London, Liverpool, Durham, Bristol, Glasgow) from which the Metrovick's apprentices are drawn. Metrovick says: "As a result of general experience it can be confidently advised that a boy should spend approximately one year in a works *before* proceeding to a university, providing that arrangements are made to continue his studies this year. This period gives a fair insight into the character of engineering work and enables a boy to judge before it is too late whether he has chosen his profession correctly. Moreover, this practical experience will be of great value in his technical studies."

They continue. "It must be borne in mind, however, that the function of workshop experience is not to develop any particular degree of manual skill or dexterity in the use of tools, but rather to give a preliminary knowledge and experience of the different kinds of tools, their design and uses.

"Subject to a satisfactory record in the works and at college the apprentices will also be accepted for a two months course of training in each of the subsequent summer vacations, and finally will be admitted as college apprentices for a period of not less than one year after graduation.

"Since the inception of this definite course of training, it has been found that the short period of industrial experiences prior to entry into a university is of the greatest value. The experience gained in this period provides a practical foundation on which to build the theoretical structure of the university course, and is of considerable assistance in giving students an understanding of the application of their theoretical training.

"The total works apprenticeship is to be not less than two years and two months." This scheme is excellent!

If Professor C. E. Inglis (Cambridge)† rejects a special training of the university graduates and recommends a general education of all students of engineering I cannot completely agree with him. Universities and colleges have the task of training the main branches of e.g. architects, civil engineers, mechanical and electrical engineers,

* Education for industry (Metropolitan-Vickers Electrical Co. Ltd., Trafford Park, Manchester) special publication No. 7985/1.

† *Journal of the Institution of Civil Engineers*, No. 1, November, 1941: Presidential address.

chemists. This is the vertical order, but horizontally all of them ought to learn mathematics, mechanics, physics, and chemistry, and further production engineering including the economic fundamentals. Then we would have an ideal education of practical engineers throughout.

In his lecture to the Institution of Electrical Engineers in March of this year Dr. Fleming said, "The problems involved will not be solved by the individual effort, however well conceived, of particular sections of industry, of education authorities, or of the universities. Each has its part to play, but the separate efforts must be linked together intimately in a national plan, and it will be wise to begin to lay the foundations now for concerted and enlightened action."

Research Department: Production Engineering Abstracts

(*Edited by the Director of Research*)

NOTE.—*The addresses of the publications referred to in these Abstracts may be obtained on application to the Research Department, Loughborough College, Loughborough.*

ANNEALING, CASEHARDENING, TEMPERING.

The Selection of Case Depth in Gear Manufacture, by I. Stewart. (*Mechanical World, May 1, 1942, Vol. CXI, No. 2887, p. 385, 7 figs.*).

Types of case depth. Thin under 0.025 in., medium 0.025 to 0.060 in., heavy over 0.060 in. The medium type of case is the most popular in gear manufacture. Failure of a worm through excessive heat and overloading. Choice of steel. Cause of probable failure. Good casehardening ruined by bad grinding technique. Pitting of gear-teeth. Chipping of gear-teeth. Fractures in gear-teeth usually occur at the root of the tooth, very often at the blending line between fillet and gear-tooth proper. Grinding—it is a very wise custom to insist that all grinding operations on casehardened work is not only "wet" but also that the minimum cut compatible with production be used. The removal of only 0.001 in. of case is sufficient to drop the hardness some 30 to 40 Vickers diamond points.

Flame-hardening. (*Aircraft Production, June, 1942, Vol. IV, No. 44, p. 419, 14 figs.*).

All forms of heat-treatment which involve the heating and quenching of the entire component are liable to result in work distortion unless special precautions are observed. It is in this connection that the shorter flame hardening process is particularly successful since, due to the fact that only a very small area is heated at any instant, and this is immediately quenched, distortion is almost entirely eliminated. Diagrammatic illustrations of the four main methods. Depth of hardness. Types of machines. Hardening irregular profiles. Quantity-production work. An automatic camshaft hardening machine showing the burners and quenches.

MACHINE ELEMENTS.

Bearings and Lubrication, by R. J. S. Pigott. (*Mechanical Engineering, U.S.A., April 1942, Vol. 64, No. 4, p. 259, 30 figs.*).

Principles of ordinary bearing. Dry journal at rest in bearing, dry journal during rotation. Unloaded lubricated journal during rotation. Shear forces in unloaded bearing. Lubricated journal in running position. The Reynolds wedge. The case of actual bearings. The function and effect of oil. Principle of Kingsbury or Michell thrust bearing. Film-pressure diagram. Effect of grooving. Conditions affected by oil groove. Use of babbitt. Connecting-rod bearing of a 1935 light eight engine. Comparison between test and calculated data. Sections of copper-lead bearing shells. Cooling of oil neglected. Exam-

ples of copper-lead bearing surfaces. New copper-lead bearings. Broached bearing. Bearing bored with a fly cutter. Troubles avoided by attention to design. Grease and solid lubrication. Ball and roller bearings.

Bearings for Heavy-duty Automotive Engines, by A. B. Willi. (*S.A.E. Journal, February, 1942, Vol. 50, No. 2, p. 62*).

Characteristics of Cd-alloy bearings and bearings with thin-babbitt linings, undersize bearings, renewal of bearings, factors causing shorter life of replacements and methods of increasing load-carrying capacity, lubrication, Cu-Pb bearings, their types and causes of failure and rules for their installation.

(*Supplied by the British Non-ferrous Metals Research Assoc.*).

Silver Lined Bearings for Aircraft Engines. (*Ind. and Eng. Chem. (News ed.), Vol. 4, No. 3, February 10, 1942, p. 191*).

Silver lined bearings are being used effectively in aircraft engines of the radial air-cooled type and also in engines designed for liquid cooling. Some of the bearings are complete rings coated inside and outside with silver and some are split and coated on the inside surface only. Silver is understood to be capable of carrying a higher load than babbitt, to be a better conductor of heat, and to retain its hardness at temperatures above those feasible with babbitt.

(*Communicated by D.S.R., Ministry of Aircraft Production*).

MACHINING, MACHINE TOOLS.

Contour Sawing Fixtures—Release other Production Machines, by H. J. Chamberland. (*The Tool Engineer, U.S.A., April, 1942, Vol. XI, No. 4, p. 72, 7 figs.*).

The revolutionary metal-cutting or shaping process known as "contour sawing" was developed about eight years ago. Heavy anti-aircraft gun slide, held in position with crane and supporting fixture to provide a 25° cut on a radius. Contour sawing saved two-thirds of time formerly required. Contour sawing applied to 15 ft. long power shovel dipper stick. Roll-feed fixture. Cutting curved part of rod. Sawing air-plane parts. Finishing Diesel wrist pins. Performing slotting operations.

Grinding Wheel Operating Speeds, by J. B. Hall. (*Machinery, May 7, 1942, Vol. 60, No. 1543, p. 415*).

The safe limit is a variable which must inevitably be considered jointly with the grinding operation involved. 75% to 80% of all abrasive wheels operate between 4,500 and 6,500 surface feet per minute. Responsibility, over speeding. Vitrified precision wheels usually limited to 6,500 surface feet per minute may be operated at the speeds up to 16,000 ft. according to a given specification. Normal maximum speed for plain wheels, cup wheels, cylinder wheels, and others.

CHIPLESS MACHINING.

Further Notes on the Practical Application of the Use of Rubber in Presswork, by F. L. Joyce. (*Machinery, May 21, 1942, Vol. 60, No. 1545, p. 467, 7 figs.*).

Illustrations show what happens when the rubber is too soft and a pressure retaining block is not used, the use of the "pressure-retaining block," arrangement of bolster and formers before the forming operation. During pressing, some parts of the bolster tend to become a solid mass. A set-up for a blanking operation.

Behind the Luftwaffe, by Paul H. Wilkenson. (*The Machinist, April 18, 1942, Vol. 86, No. 1, p. 26, 10 figs.*).

Over one-third of Germany's Henschel Hs-126 observation plane is made of metal stampings. Illustrations : Bulkhead rings for the fuselage of German planes are rolled to shape on automatic forming machines. Fairings and other sheet-metal coverings of special contour are drawn to shape on stretching presses. Nose sections of wing ribs are formed under rope-operated drop hammers using metal dies and rubber platens. Hydraulic presses are used to form many structural members of the Henschel observation plane. Jigs for assembly of Henschel wings. The wing skeletons are converted into wing frames. The skin is applied to the wing-panel assemblies. Box jigs are used for mating the centre and rear sections of the fuselage.

MANUFACTURING METHODS.

Spinning Methods, by J. G. Magrath. (*The Machinist, April 18, 1942, Vol. 86, No. 1, p. 8, 7 figs.*).

Flame hardening by spinning takes a more expensive set-up but where quantities justify it the process pays for itself. Illustrations : Four torches simultaneously heat the main bearings of a crankshaft, then the flames are extinguished and the bearings quenched. Small parts may be flame hardened on the outside by the circular band spinning method. Circular band opening is also applied to inside circular surfaces of small parts. Speed of spinning. Long cylindrical surfaces lend themselves to flame hardening by the progressive spinning method. A vertical machine fitted for surface hardening. Long inside cylindrical surfaces hardened by progressive spinning.

Piston Manufacture. (*Automobile Eng., April, 1942, Vol. 32, No. 422, p. 137*).

A detailed account of manufacture and inspection of pistons of light-alloy castings and forgings.

(*Supplied by the British Non-ferrous Metals Research Assoc.*).

The Fabrication of Monel, Nickel, and Inconel Seamless Pipe and Tubing. (*Sheet Metal Industries, June, 1942, Vol. 16, No. 182, p. 823, 1 fig.*).

Cutting speeds of approximately 15 ft. to 20 ft. per minute for Monel and nickel and 10 ft. to 15 ft. per minute for Inconel give good results. It is necessary to keep the cutters sharp at all times and as soon as they start to dull they should be removed. Lathe threading. Oxy-acetylene welding. Oxygen control. Fluxes. Silver soldering. Bending and coiling. Arrangement of loading and quenching tanks for the handling of tubing in continuous production work. Rod-heating furnaces, open front and back and fired from one or both ends, are best for heating tubing for bending.

Fortress II in Production. (*Aircraft Production, June, 1942, Vol. IV, No. 44, p. 409, 6 figs.*).

Triple works scheme in operation for Boeing B.17 E.

MATERIALS, MATERIAL TESTING.

Industrial Progress in Synthetic Rubberlike Polymers, by H. I. Cramer. (*Ind. and Eng. Chem. (Ind. ed.), Vol. 34, No. 2, February, 1942, pp. 243-251*).

The development of synthetic rubberlike polymers is being accelerated greatly by the national emergency. The annual production of these new

vital materials has now increased to the point where it can be expressed in tens of thousands of tons. Formerly the application of the synthetic rubbers depended upon their superiority in some specific respects over natural rubber. With the completion of the new plants now planned and under construction in the U.S.A., sufficient of the synthetic product should become available so that attention can be given to those tonnage applications involving simple replacement of the natural product. Over a score of synthetic elastic polymers have been produced on a commercial scale. The discussion is limited to a review of the raw materials required, the commercial syntheses, applications, and costs of the polymers of butadiene or derivatives, the polybutenes, the alkylene polysulphides, and the plasticised polyvinyl chlorides. The production capacity of synthetic rubber plants in the United States built and in the course of construction is discussed.

(Communicated by D.S.R., Ministry of Aircraft Production).

Improvement in Light Alloy Screw Connections, by H. Cornelius. (*Z.V.D.I., Vol. 86, No. 13-17, April 4, 1942, pp. 218-219*).

Experiments were carried out with light alloy screws and nuts of the sizes M 10 × 1.5 and M 6 × 1 (metric pitch of 1.5 and one mm., outside diameter of thread 10 and six mm. respectively). The alloy (composition not stated) is known under the trade name Duriness (Lauta works) and is stated to be specially suited for automatic screw cutting, yielding a smooth tooth flank. The screws and nuts were anodically oxidised (exolated) and subsequently impregnated with a special wax compound. The tests show that the screws treated as above could be stressed almost to the limit of the tensile strength of the thread core without any tendency to seizure in the threads. It is stated that the new process is specially to be recommended for light alloy screws requiring frequent dismantling.

(Communicated by D.S.R., Ministry of Aircraft Production).

MEASURING METHODS AND APPARATUS.

The Accurate Recording of Tyre Profiles, by C. W. Newberry. (*Engineering, May 8, 1942, Vol. 153, No. 3982, p. 361, 9 figs.*).

From the earliest days of transport by rail, the problem of providing the most suitable tyre contour has engaged the attention of engineers. Link-motion pantograph recorder. Slide-motion pantograph recorder. The "Maco" adjustable template. Experiments were made to ascertain the feasibility of forming a cast of the tyre profile. Plaster of Paris was found unsuitable for use in the shops. Merits of plasticine were next considered. The removal of the plasticine without deforming it. Profile records were printed by exposure of suitable photographic paper to daylight. Printing by chemical means, e.g., the action of hydrogen-sulphide gas.

MECHANICS, MATHEMATICS.

The "Cookson" Triangulation System : I—Precision Development, by W. Cookson. (*Sheet Metal Industries, June, 1942, Vol. 16, No. 182, p. 837, 3 figs.*).

Method of triangulation. Rectangular to round transformer. Formulae for obtaining true length lines. Description of pattern lay-out. Off-centre rectangular to round transformer. Similarity of formulae.

PHYSICS.

The Production of High Vacua, by James F. Driver. (*Machinery Lloyd, May 16, 1942, Vol. XIV, No. 10, p. 39, 9 figs.*).

Mechanical pumps. Diagrammatic view of rotary mercury pump. Diagrammatic view of molecular pump. Single stage "Edwards" rotary pump. Geryk large capacity rotary vacuum pump. Vacuum .0005 mm. mercury. Geryk multi-unit rotary pump. Vacuum .00001 mm. mercury. Diagram showing operation of diffusion pump. Edwards' type 4 diffusion pump with electric heater. Edwards' type 120 diffusion pump with Edwards type 4 as backing pump in series.

PLASTIC MATERIAL.

Plastics—a New Method of Construction, by C. Chapman. (*Transactions of the Institution of Engineers and Shipbuilders in Scotland, April, 1942, Vol. 85, Part 6, p. 277*).

Types of substances: Thermo-plastics, nitro-cellulose, cellulose acetate, casein, styrol, vinyl and acrylic resins, coal tar resins, butadiene, and allied plastics. Thermo-setting: Phenol-formaldehyde, urea-formaldehyde, glycerine-phthalic anhydride. Moulding of thermo-plastic materials, Shaping by heating and cooling under pressure is almost obsolete, because of the high cost. Injection is by far the most usual way of moulding rigid thermo-plastic articles. Blowing is of rather limited application. Extrusion from a cylinder can be used with celluloid, cellulose acetate, casein, and the newer plastics such as polyvinyl chloride. The lengths produced are, of course, limited by the charge which enters the cylinder. Forcing resembles extrusion but unlimited lengths of the constant section are produced. Moulding of thermo-setting materials is using: (1) Heat and pressure moulding, (2) casting, (3) extrusion, (4) multi-daylight pressing. Characteristics of various plastics.

SHOP MANAGEMENT AND EQUIPMENT.

Notes on Process Planning. (*Machinery, May 28, 1942, Vol. 60, No. 1546, p. 495, 5 figs.*).

Preliminary survey and assembly planning. Organisation chart, showing assembly group planning as used in the aircraft industry. A usual type of operation or process sheet. The human side of process planning. Methods used in process planning. Process drawings. A type of process drawing which is used without a process sheet. Assembly sheets.

SMALL TOOLS.

Cemented Carbide Tools. (*Automobile Engineer, March, 1942, Vol. XXXII No. 421, p. 91*).

Details are given of the most recent available information concerning the treatment and application of cemented carbide tools in Germany. Methods of preparing and fixing the tip of the shank are described, as are the methods of grinding necessary to ensure optimum results. Tool angles are fully discussed and limited values for clearance angle, top rake angle, and side slope of the top rake for a wide range of materials are set out in tabular form. These angles are based on practical experience. Cutting speeds are of primary importance in the use of tipped tools, and valuable information is included concerning the speeds to be used for rough and finish turning for all materials that are commonly machined by means of carbide tipped tools.

Modern Lathe Practice—*XIV*, by F. Horner. (*Practical Engineering, April 30, 1942, Vol. 5, No. 119, p. 388, 16 figs.*).

Some of the most useful profiles for tool-holder cutters. Straight and drop-head holders with fixed top rake. Holder with forged lip. Cam-lock holder. Holder for supporting stellite bit safely. Holders with fixed front rake. Standard cutters for holder having pin fastening. Tool-holders for grooving and parting. Divided holder for small cutting-off blades. Divided holder taking dovetail section parting steel.

The Design of Drawing Dies, by C. P. Bernhoeft. [*Met. Ind.* (*Lond.*), *March 20, 1942, Vol. 60, No. 12, p. 204*].

Characteristics of diamond and hard-alloy dies, design and dimensions, polishing the drawing hole, calculation of drawing surface and drawing cone.

(*Supplied by the British Non-ferrous Metals Research Assoc.*).

Cutting Threads close to a Shoulder with Self-opening Die-heads. (*Machinery, May 21, 1942, Vol. 60, No. 1545, p. 463, 11 figs.*).

STANDARDISATION.

Machine Tool Electrical Standards—V and VI. (*The Machinist, Reference Book Sheet, April 18, 1942, Vol. 86, No. 1, p. 31*).

Mounting. Panel wiring. Type of control. Type of motor. Mounting of motors. Balance. Starters. Nameplates. Wiring standards. Type of conductors. Control wiring. Identification of wires. Reduced-voltage control circuits. Conduit and wire runways. Stationary equipment. Moving machine parts. Portable and pendant equipment. Connections to accessories. Marking of accessories.

American Standard Jig Bushings—I and II. (*The Machinist, Reference Book Sheet, April 25, 1942, Vol. 86, No. 2, p. 99, 6 figs.*).

Press fit bushings. Renewable bushings. Liner bushings. Bushing specifications. Jig plate thickness.

SURFACE, SURFACE TREATMENT.

Economic Degreasing of Metal Parts with Trichlorethylene, by A. R. Angus. (*Mechanical World, May 29, 1942, Vol. CXI, No. 2891, p. 479, 4 figs*).

A complete Fraser-Heller degreasing plant unit. Cross-section of washing tank. General arrangement of plant with medium-sized washing tanks.

TECHNICAL INFORMATION.

A Select Bibliograph on the Machining of Metals. (*Research Bulletin, No. 6, Sheffield City Libraries, May, 1942*).

Covers approximately the period 1935 to date. Contents: Principles of cutting; materials used for cutting tools, carbon and alloy tool steels, heat treatment of carbon and alloy steels, high speed steels, hard carbides, diamond tools, etc., machineability and machining operations, gear cutting, and other specific machining operations, lathe tools and lathe operation, planer tools, shapers, and slotters, boring and boring tools, milling and milling cutters, broaches and broaching, grinding and grinding machines, flame machining.

American Aircraft Production (Figures and Estimates). (*Inter Avia No. 808-809, March 28, 1942, p. 1*).

Official statistics on the production of American aircraft material have only been published up to September, 1941. Making reasonable assumptions for the remaining three months of that year, the author estimates that a total of 20,000 aircraft, 30,000 engines (1,000 h.p. or more each) and less than 30,000 v.p. propellors were produced during the whole of 1941. The 20,000 aircraft included about 11,000 combat machines of which 6,500 were exported (mainly to Great Britain). According to an official statement of the Aeronautical Chamber of Commerce, by the end of 1941, the aircraft labour force amounted to 390,000 persons, and the factory space to 46 million square feet. For 1942 and 1943 annual production of 45,000 and 100,000 combat machines are aimed at. As long ago as 1940, T. P. Wright estimated that a labour force of 800,000 persons and a factory space of 90 million square feet would be required for an annual output of 50,000 aircraft. In addition to the construction of new plants, a prodigious expansion of the already vast American motor car industry is thus called for.

(*Communicated by D.S.I.R., Ministry of Aircraft Production*).

Progress in Machine Tools *1932-1942*, by Tell Berna. (*The Tool Engineer, U.S.A., March 1942, Vol. XI, No. 3, p. 78*).

In the year of 1932 total business of the entire industry amounted to only $22,000,000. It is hoped that the industry this year will be able to turn out $1,500,000,000 worth of machine tools—no less than ten times normal production. Over 100,000 men are building machine tools. It is estimated that average productivity of machine tools built to-day is several times that of machines built ten years ago. Widespread adoption of tipped tools necessitated the complete redesign of some machines in order to back them up with increased power, afford higher speeds, and greater rigidity. Increased productions and greater accuracy of all types of machine tools have been supplemented by greater convenience.

WELDING, BRAZING, FLAME CUTTING.

Application of Welding in the Design of Machine Tools, by F. Koenigsberger. (*Welding, May, 1942, Vol. X, No. 4, p. 75, 15 figs.*).

Difficulties due to the mechanical properties of cast iron. Difficulties created by the casting process. Advantages of welded design: (1) Strength of the structure, (2) resistance to deformation, (3) resistance to vibration, (4) economy of design and construction. Press of fabricated steel construction (Henry Pels). Fabricated heavy press. Fabricated press upright. Fabricated upright for a rotary shear. Section through the fabricated upright of a hammer. Base plate for a radial drill. Diagrammatic section, elevation, and plan of lathe bed.

Gas Cutting—Results Produced by Correct and Incorrect Procedure, by H. H. Moss. **" Correct Procedures *v.* Common Faults in Hand-cutting.** (*Welding Journal, February, 1942, Vol. 21, p. 119*).

The chart reproduced is designed to assist in controlling gas-cutting operations on the basis of typical effects resulting from varying conditions of operation.

WELFARE, SAFETY, ACCIDENTS.

Magnesium Fires. (*Metal Industry, Vol. 60, No. 15, April 10, 1942, p. 158*).

According to a U.S. Bureau of Mines report, a new and more effective method of extinguishing magnesium (fuses, etc.) fires in commercial plants have been developed by the Bureau. Whilst designed for places where magnesium is being handled continuously the method is said to be equally effective against incendiary bombs in war-time. Hard coal-tar pitch in granulated or flaked form is said to be a highly satisfactory substance for extinguishing a magnesium flame, as the pitch softens and forms an ait-tight blanket which quickly smothers the flame. This method is regarded as superior to the use of sand and water, or prepared compounds such as carbon tetrachloride, carbon dioxide, and foam. Powdered pitch should not be used, as it has explosive characteristics similar to those in coal and other dusts. Further advantage claimed for pitch for use in industrial plants is that it is not abrasive and not likely to damage costly machinery.

(*Communicated by the D.S.I.R., Ministry of Aircraft Production*).

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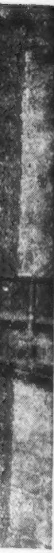

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